DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

ELECTRICAL CIRCUIT ANALYSIS LAB MANUAL

G. NARAYANAMMA INSTITUE OF TECHNOLOGY AND SCIENCE.

(FOR WOMEN) (AUTONOMOUS)

SHAIKPET, HYDERABAD. 500104

Department of Electrical & Electronics Engineering

II Year B.Tech I-Semester, EEE   A.Y: 2023-2024

ELECTRICAL CIRCUIT ANALYSIS LAB (12314)

1. Determination of Self and Mutual inductance in a Coupled Circuit. Determination of Coefficient of Coupling.
2. Verification of Thevenin's and Norton's Theorems. (with A.C. Excitation)
3. Verification of Superposition and Maximum Power Transfer Theorems. (with A.C. Excitation)
4. Locus Diagrams of RL and RC Series Circuits.
5. Generation of various signals and sequences (unit Impulse, Step, Square, saw tooth, Triangular, Sinusoidal, Ramp) and operations on signals and sequences (Addition, Multiplication, Scaling, Shifting, Folding, Computation of Energy, and Average Power) using software.
6. Simulation of Transient response of RL, RC and RLC Circuits.

7. Measurement of Active Power for Star and Delta connected balanced loads using two-wattmeter method.
8. a) Time response of first order RL network for periodic non – sinusoidal inputs – Time constant and Steady state error determination.
   b) Time response of first order RC network for periodic non – sinusoidal inputs – Time constant and Steady state error determination.
9. a) Two port network parameters Z & Y parameters - Analytical verification.
   b) Two port network parameters Transmission Line & Hybrid parameters - Analytical verification.
10. Waveform Synthesis using Laplace Transforms.

(Narmada Byreddy)   (Dr.P.Ramakrishna Reddy)
 Faculty In-charge,   HOD-EEE.
 ECA lab.

Self and Mutual inductance in a Coupled Circuit.

Aim: Determination of self and mutual inductance in a coupled circuit. Determination of co-efficient of coupling.

Apparatus:

S.NO.	Name of the Apparatus	Range	Quantity
1	1-phase Transformer	115/230V 1KVA	1
2	Voltmeter	0-360V/600V(MI)	2
3	Ammeter	0-1A/2A(MI)	1
4	1-phase variac	230V/0-270V	1
5	Digital multimeter	-	1
6	Connecting wires	-	As required

Name plate details of Single phase transformer:
KVA: 1
Phase:1-phase, 50Hz
V-primary: 230V, A-primary: 4.35A
V-secondary: 115V, A-secondary: 81.74A
Type: 1-phase, DW.

Theory:

Self Inductance(L) : When a current is changing in a circuit, the magnetic flux linking the same circuit changes and an emf is induced in the circuit. We can derive an expression for the self-inductance of a coil from Faraday's law of electromagnetic induction.

$V_L = -N (d\phi / dt)$

Where:

V_L = induced voltage in volts

N = number of turns in the coil

$d\phi / dt$ = rate of change of magnetic flux in webers / second

Alternatively, the induced voltage in an inductor may also be expressed in terms of the inductance (in henries) and the rate of change of current.

$V_L = -L (di / dt)$ volts

Or

$E = -L (di / dt)$ volts

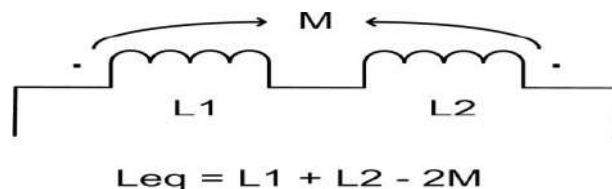## Self and Mutual inductance in a Coupled Circuit.

Mutual Inductance(M): When two coils are brought in proximity to each other, the magnetic field in one of the coils tends to link with the other. This further leads to the generation of voltage in the second coil. The amount of flux linked with the second circuit depends on the geometry of two circuits and in the absences of any non-linear magnetic materials, it will be proportional to the current in the first circuit. This property of a coil which affects or changes the current and voltage in a secondary coil is called mutual inductance. Has same unit as self-inductance.

Series Aiding: When the two coils are connected for additive polarity, the fluxes produced by the current in the two coils will aid each other and hence the impedance is high. In this case the mutual inductance terms will have the same sign as that of the self-inductance terms. Thus, if the two coils having inductance $L1$ and $L2$ respectively and a mutual inductance of M between them are connected for additive polarity, the equivalent inductance $Leq = L1+L2+2M$.

$$Leq = L1 + L2 + 2M$$
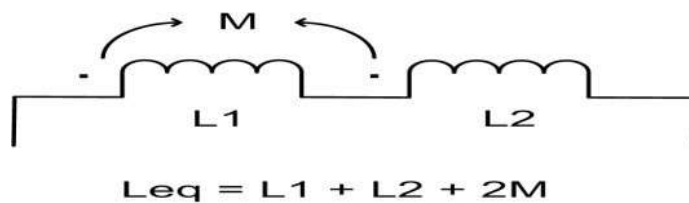
Series Opposing:
    When the two coils are connected for subtractive polarity, the two fluxes will oppose each other and the inductance and hence the impedance is low. In this case the mutual inductance terms will have the opposite sign as that of the self inductance terms. Hence the equivalent inductance $Leq=L1+L2-2M$

$$Leq = L1 + L2 - 2M$$

Thus the coefficient of coupling is calculated by the formulae $Leq=L1+L2+2M$ henery

$Leq=L1+L2-2M$ henery

$$K = M/\sqrt{L_1 L_2}$$

2
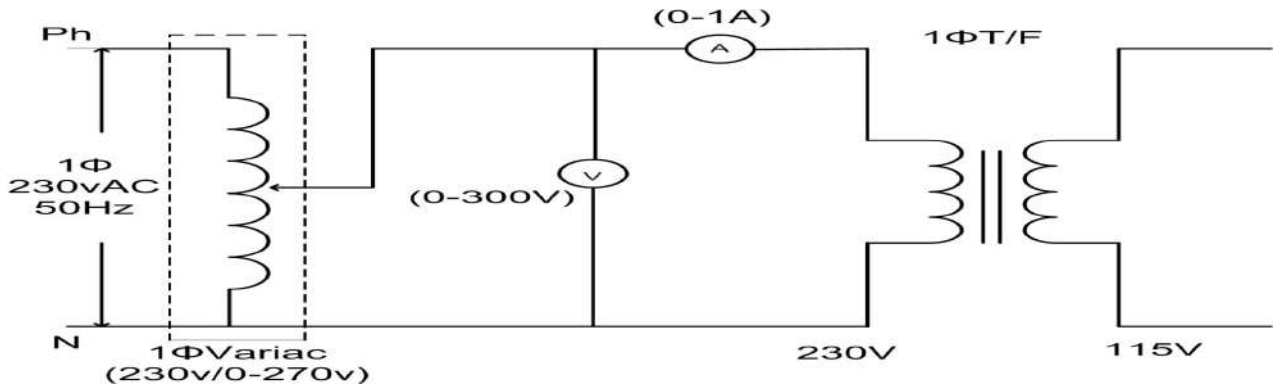
II B.Tech-I Semester   Experiment No:1

Self and Mutual inductance in a Coupled Circuit.

CIRCUIT DIAGRAMS:

Circuit(1): Circuit to find L1.

Tabular column for L1:

S.No	V_1 (V)	I_1 (A)	$Z_1 = V_1/I_1$ (Ω)	$X_1 = \sqrt{Z_1^2 - R_1^2}$ (Ω)	$L_1 = X_1/\omega$ (H)

Circuit (2): Circuit to find L2.
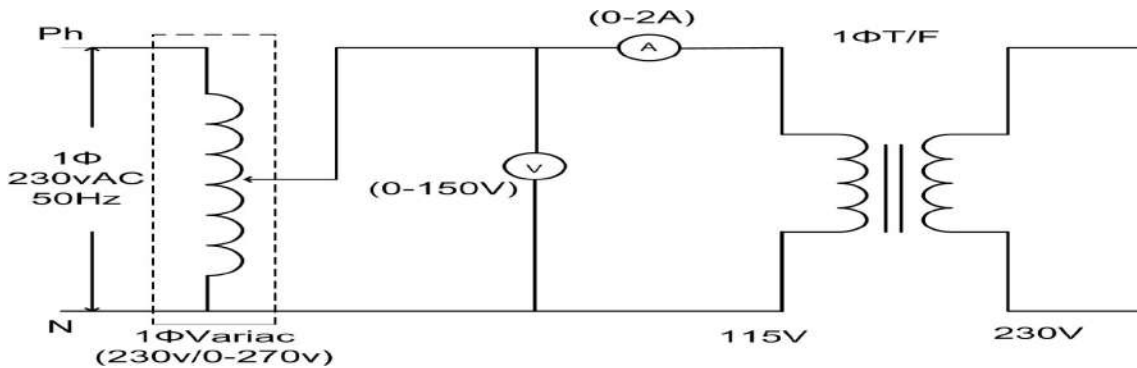
Tabular column for L2:

S.No.	V_2(volts)	I_2(amps)	$Z_2 = V_2/I_2$(Ω)	$X_2 = \sqrt{Z_2^2 - R_2^2}$ (Ω)	$L_2 = X_2/\omega$ (H)

Self and Mutual inductance in a Coupled Circuit.
Circuit(3): Circuit to find L_{Eq}

Tabular column for Leq:

S.No	V(volts)	I(amps)	Zeq=V/I(Ω)	$X_{eq} = \sqrt{Z_{eq}^2 - R_{eq}^2}$ (Ω)	Leq=Xeq/ω(H)

Calculations:

II B.Tech-I Semester   Experiment No:1

Self and Mutual inductance in a Coupled Circuit.

Procedure:

For determination of L1:
1. Connections are made as shown in circuit (1).
2. Rated voltage is applied through the variac and corresponding readings of V and I are noted.
3. Resistance of the winding is measured using multimeter
4. Unknown parameter is calculated.

For determination of L2:
1. Connections are made as shown in circuit (2).
2. Rated voltage is applied through the variac and corresponding readings of V and I are noted.
3. Resistance of the winding is measured using multimeter
4. Unknown parameter is calculated.

For determination of Leq:
1. Connections are made as shown in circuit (3).
2. Voltage is applied through the variac and corresponding readings of V and I are noted.
3. Resistance of the winding is measured using multimeter
4. Unknown parameter is calculated.

Result:

II B.Tech-I Semester   Experiment No:1

EXPERIMENTAL VERIFICATION OF THEVENIN'S AND NORTON'S THEOREMS WITH AC EXCITATION.

Aim: Verification of Thevenin′s and Norton′s theorems with AC excitation both theoretically and practically.

Apparatus:

S.NO.	Name of the Apparatus	Range	Quantity
1	1-phase variac	230/0-270 V	1
2	Rheostat	100Ω/5A	3
3	Resistor	50Ω 20Ω	2 1
4	Inductor	1-phase variable	2
5	Ammeter	0-2A	1
6	Digital Multimeter	-	1
7	LCR meter	-	1
8	Connecting wires	-	-

Safety pre-cautions:

1. There should not be any loose connections in the circuit.

2. Circuit connections have to be verified by the concerned staff member before switching on the supply.

3. Do not touch any instrument in the circuit when the supply is on.

4. Readings have to be taken without parallax error.

5. Variables supplies should be made zero before turning off the main supply.

6. In case of any sparks or wire burning smell, Unplug or power off any device causing the fire, if it is safe to do so. The breaker box is another option to turn off the power immediately.

Theory:

Thevenin's theorem:

Statement – In any linear, bilateral network with several voltage/ current sources and impedances can be replaced by a single equivalent voltage source(Thevenin voltage-V_{th}) in series with a single equivalent impedance(Thevenin impedance-Z_{th}) connected in series with the load. The equivalent voltage source is the open circuit voltage measured across the load terminals and the equivalent impedance is the impedance measured across the load terminals across the load terminals by replacing the sources with their internal resistance, i.e., short circuiting the voltage sources and open circuiting the current sources. The basic procedure for solving a given circuit using Thevenin's theorem is as follows: (Theoretical procedure)

1. Find the current flowing through the load resistor R_L.
2. Find V_{Th} by the usual circuit analysis methods.
3. Remove the load resistor R_L or component concerned.
4. Find Z_{Th}(equivalent impedance)by shorting all voltage sources or by open circuiting all the current sources. Solve the network to Z_{Th} find the equivalent impedance using any one of the network reduction techniques.
5. Draw the equivalent circuit with V_{Th} in series with Z_{Th} and load resistor. Find the current flowing through the load resistor. If the current in step 1 and step 5 are same, then the Thevenin's theorem is verified.

Norton's theorem:

Statement – In any linear, bilateral network with several voltage/ current sources and impedances can be replaced by a single equivalent current source (Norton's current-I_N) in parallel with a single equivalent impedance (Norton's equivalent impedance-Z_N) connected in parallel to the load. The equivalent current source is the short circuit current measured by shorting the load terminals and the equivalent impedance is the impedance measured across the load terminals by replacing the sources with their internal resistance, i.e., short circuiting the voltage sources and open circuiting the current sources.

The basic procedure for solving a given circuit using Norton's theorem is as follows: (Theoretical procedure)

1. Find the current flowing through the load resistor R_L.
2. Find I_N by usual circuit analysis methods after short circuiting the load terminals.
3. Remove the load resistor R_L or component concerned.
4. Find Z_N (equivalent impedance) by shorting all voltage sources or by open circuiting all the current sources. Solve the network to Z_N find the equivalent impedance using any one of the network reduction techniques. (Note: As Thevenin's and Norton's Theorems are done together, Z_N will be same as Z_{Th}.)
5. Draw the equivalent circuit with I_N in parallel with Z_{Th} and also load resistor. Find the current flowing through the load resistor. If the current in step 1 and step 5 are same, then the Norton's theorem is verified.
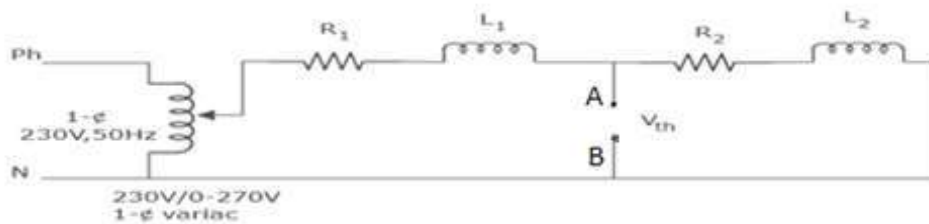
Note: Students are expected to do the theoretical analysis prior to the experimental analysis to choose proper meters.
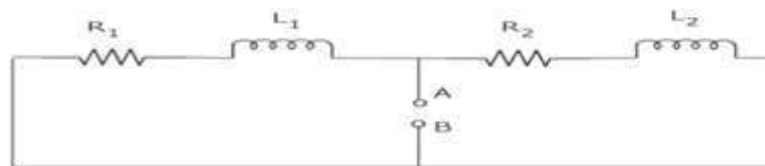
CIRCUIT DIAGRAMS:

Circuit-1: Main circuit: To find current through the load resistor. (Common for BOTH Thevenin's and Norton's Theorems)
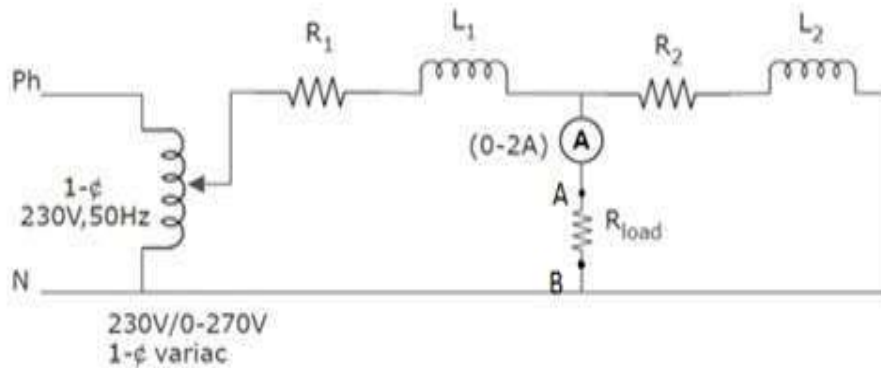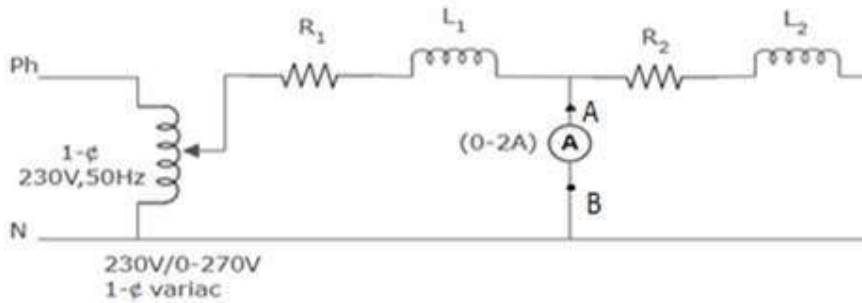

Circuit-2: To measure Thevenin voltage V_{Th}:

Circuit-3: Circuit to find Z_{th}: R_{th} & L_{th} are measured across terminals A& B, using appropriate meters:
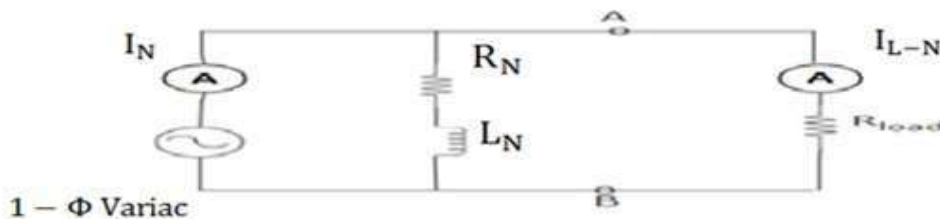

Circuit-4: Thevenin's Equivalent Circuit.

Circuit-5: Circuit for measuring Norton's current(I_N) :

Circuit-6: Norton's Equivalent circuit:

Observations:

Given: $R_1 =$; $R_2 =$; $R_L =$; $L_1 =$; X_1 ; $L_2 =$; $X_2=$; (With respective units)

Tabular column for Thevenin's Theorems:

Input voltage (V_{in}) V.	Load current(I_L); (From circuit-1) in Amps.	Thevenin's voltage(V_{th}) V.	Equivalent Impedance $Z_{Th}=$ $R_{Th}+jX_{Th}$ (Or) $Z_N=R_N+jX_N$ in ohms.	Thevenin's equivalent current(I'_{L-Th}) (A).	Verification of the theorem. $I_L = I_{L-Th}$.

Tabular column for Norton's Theorems:

Input voltage (V_{in}) V.	Load current (I_L); (From circuit-1) in amps.	Norton's current(I_N) (A).	Equivalent Impedance $Z_{Th}=$ $R_{Th}+jX_{Th}$ (Or) $Z_N=R_N+jX_N$ in ohms.	Norton's equivalent current(I_{L-N}) (A).	Verification of the theorem. $I_L = I_{L-N}$.

Calculations:

Procedure (Experimental verification) :

Thevenin's Theorem:

1. Connections are made as shown in circuit -1, with appropriate values of passive elements and source.
2. Excitation (Ex: 25 V, 50V, etc.,) is given and the response in the load ammeter (I_L) is measured.
3. To find equivalent voltage (V_{Th}), the voltmeter is connected across the terminals A & B in circuit-2, and V_{Th} is measured by giving the excitation to the circuit.
4. The terminals where the voltage source is connected are short circuited and the load resistance (R_L) between the terminals A & B is removed as shown in circuit -3.
5. The equivalent resistance and inductance are measured at the terminals A & B by using a LCR meter and reactance is calculated.
6. Thevenin's equivalent circuit has to be connected as shown in figure-4.
7. The source value to set equal to the Thevenin voltage (V_{th}), and the response in the ammeter is the load current corresponding to the modified circuit as per Thevenin theorem. Let it be Thevenin load current (I_{L-Th}).
8. If $I_L = I_{L-Th}$, Thevenin theorem is verified for the given circuit.

Norton's

1. Connections are made as shown in circuit -1, with appropriate values of passive elements and source.
2. Excitation (Ex: 25 V, 50V, etc.,) is given and the response in the load ammeter (I_L) is measured.
3. Equivalent impedance (Z_N) is combination of equivalent resistance (R_N), and equivalent inductive reactance (X_n), hence they have to be measured separately.
4. The terminals where the voltage source is connected are short circuited and the load resistance (R_L) between the terminals A & B is removed as shown in circuit -3.
5. The equivalent resistance and inductance are measured at the terminals A & B by using a LCR meter and reactance is calculated.
6. To calculate the Norton's current, disconnect the load resistor and connect an ammeter between the terminals A & B, as shown in circuit-5, and I_N is measured by giving the excitation to the circuit.
7. Connect the Norton's equivalent circuit as shown in circuit- 6, to verify the Norton's equivalent current (I_{L-N}).
8. If $I_L = I_{L-N}$, Thevenin theorem is verified for the given circuit.

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Result:

Comparison table:

Parameter (Mention the units)	Theoretical value	Practical value
Load current(I_L)		
Thevenin's voltage(V_{Th})		
R_{Th} or R_N		
X_{Th} or X_N		
Equivalent Impedance (Z_{Th} or Z_N)		
Norton's current(I_N)		
Thevenin's equivalent current(I_{L-Th})		
Norton's equivalent current(I_{L-N})		

Verification of Superposition and Maximum Power transfer Theorems (with A.C excitation).

Aim: Verification of (a) Superposition theorem and (b) Maximum Power transfer theorem, both theoretically and practically.

(a) Superposition theorem:

Apparatus:

S.No.	Name of the equipment	Range	No. required
1.	1-Φ variac	230/0-270 / volts	2
2.	Rheostat	100Ω / 5 A	4
3.	1-Φ Inductor	50 – 240 mH	1
4.	Ammeter	0-2 A	1
5.	Voltmeter	0-300 V	2
6.	LCR meter		1
7.	Digital Multimeter		1
8.	Connecting wires		

Theory:
<u>Statement of Superposition theorem:</u>

In a network with linear, bilateral elements consisting of a two or more sources, the response in any branch is equal to algebraic sum of the responses due to individual sources taken one at a time with all other sources reduced to zero, i.e., all other independent voltage sources replaced by short circuits and all other independent current sources replaced by open circuits. When a network consists of several sources, this theorem helps us to find the current in any branch easily, considering only one source at a time.

Limitations:
1. Power cannot be verified by using Superposition theorem.
2. Not applicable to unbalanced bridge circuit.

Note: Theoretical analysis of the experiment has to be done before the conduction of the experiment to design the proper range of the meters used in the experiment.

<u>Circuit Diagrams for verification of Superposition theorem:</u>

Circuit (i): With both sources (A &B) active.

Circuit (ii): With Source - B shorted.

Source-A   Source-B: Shorted
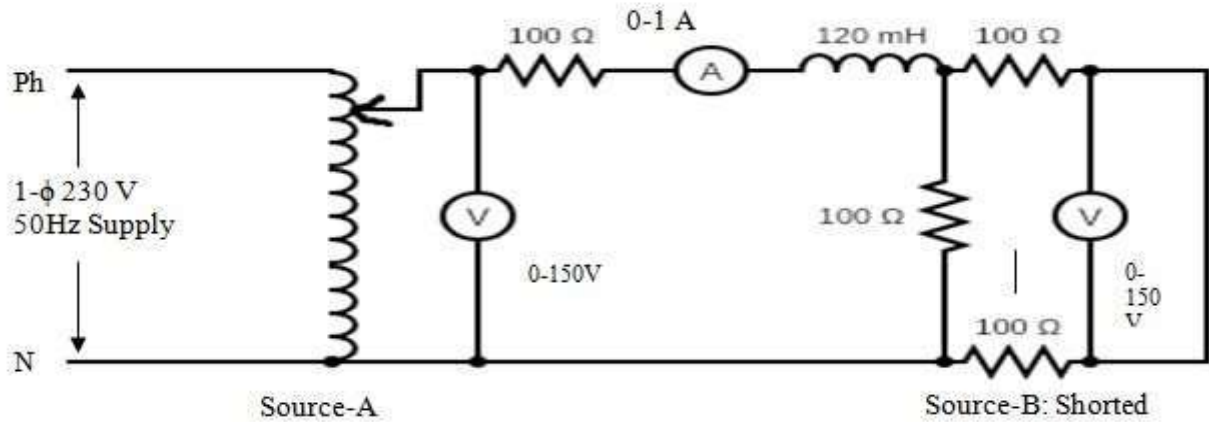
Circuit (iii): With Source-A shorted.

Source-A: Shorted   Source-B
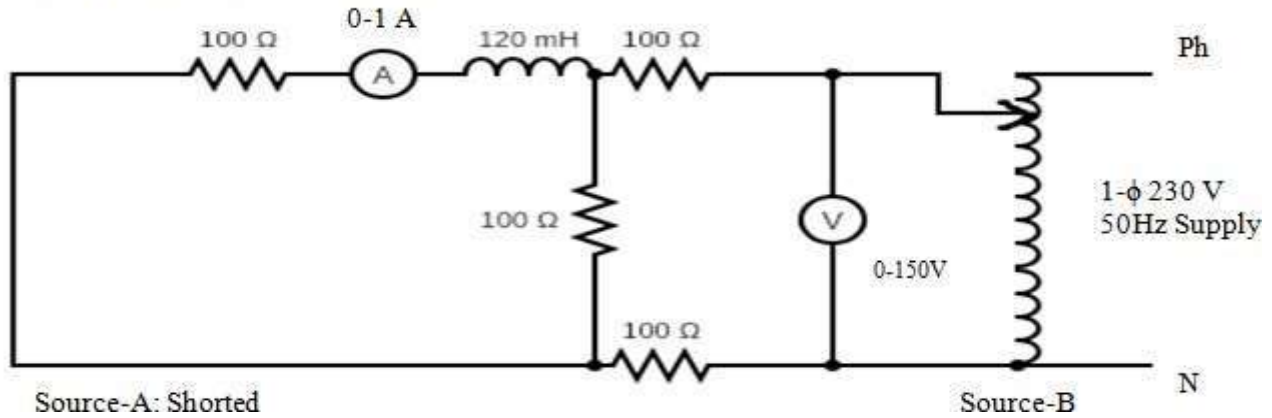
Tabular Column for Verification of Superposition theorem:

S.No.	Voltage Source (volts)	Response due to A &B (I) (amperes)	Response due to A- (I_1) (amperes)	Response due to B- (I_2) (amperes)	Algebraic sum of I_1 & I_2=I'. (amperes)
1.	$A(V_1)$ & $B(V_2)$		--	--	--
2.	$A(V_1)$	--		--	
3.	$B(V_2)$	--	--		
	Superposition theorem is for the given circuit if $I=I'$.				

Procedure for verification of Superposition theorem:

1. Connections are made as per the circuit (i).
2. Excitation is given to the circuit using the variac A& B respectively, and the response 'I' is noted.
3. Steps 1& 2 are repeated for circuit (ii) with necessary modifications in the circuit connections and response current I_1 is noted.
4. Steps 1& 2 are repeated for circuit (iii) with necessary modifications in the circuit connections and response current I_2 is noted.
5. Theorem is verified by checking the condition, "The algebraic sum of the responses in steps 3 and 4 has to be same as the response in step 2."

Theoretical Calculations:

Result:

Theoretical values(in A)	Practical values(in A)
$I =$	$I =$
$I_1 =$	$I_1 =$
$I_2 =$	$I_2 =$
$I' = I_1 + I_2 =$	$I' = I_1 + I_2 =$

(b) Verification of Maximum Power transfer theorem:

Statement of Maximum Power transfer theorem: The maximum power transfer theorem states that in a linear , bilateral DC network , maximum power is delivered to the load when the load resistance is equal to the internal resistance of a source. If it is an independent voltage source, then its series resistance (internal resistance Rs) or if it is independent current source, then its parallel resistance (internal resistance Rs) must equal to the load resistance RL to deliver maximum power to the load. This theorem gives the impedance conditions in AC circuit for maximum power transfer to a load. It states that in an active AC network consisting of source with internal impedance Z_S which is connected to a load Z_L, the maximum power transfer occurs from source to load when the load impedance is equal to the complex conjugate of source impedance Z_S.

Circuit Diagrams:

Main circuit for verification of Maximum power transfer theorem (for theoretical calculations):
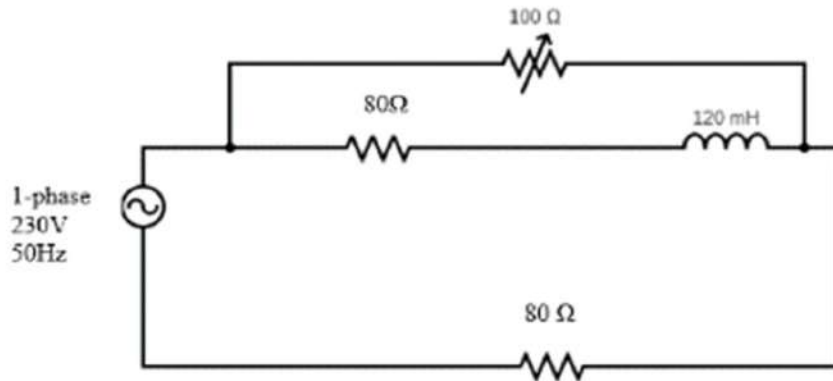
Main Circuit with appropriate meters:
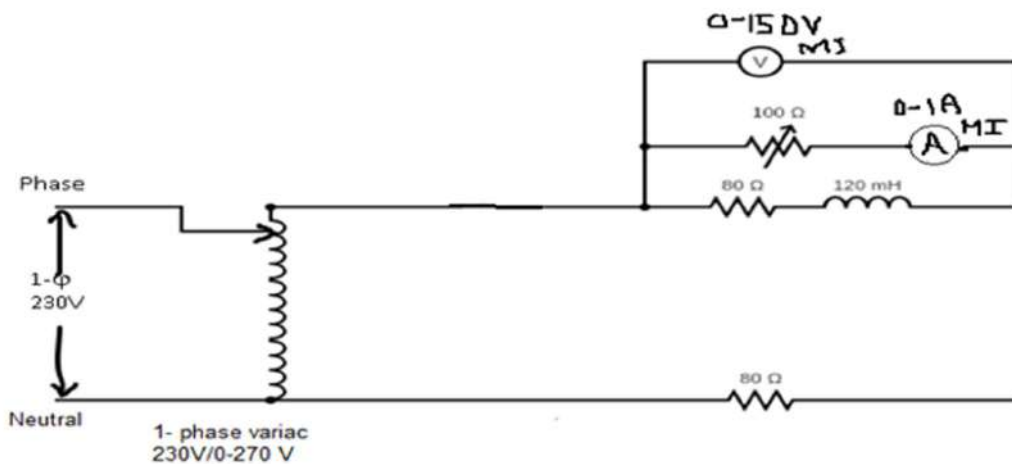
Tabular Column:

S.NO.	Load Voltage, V_L in volts	Load Current I_L, in amps	$R_L = V_L / I_L$ (ohms)	$P = I^2 Z_L$ in watt.

Expected Graph:
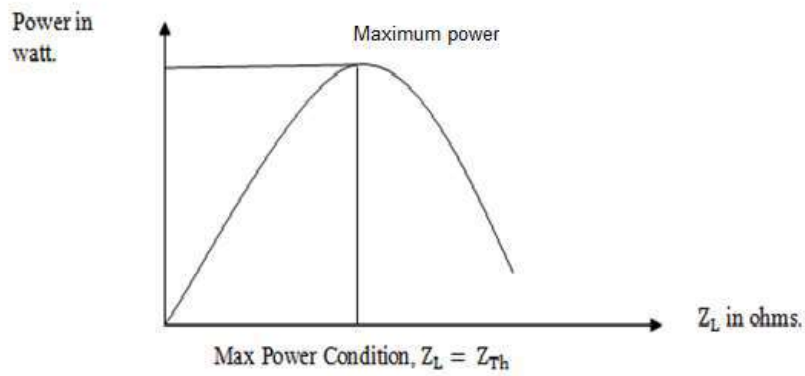
Power in watt. — Maximum power — Z_L in ohms.

Max Power Condition, $Z_L = Z_{Th}$

Calculations:

Procedure:

1. Connections are made as per the circuits shown above.
2. Keep the variable rheostat in maximum position
3. Apply the rated voltage (230V) through variac.
4. Voltmeter and ammeter readings are noted by varying the rheostat from maximum to minimum.
5. Graph is plotted between power (y-axis) and impedance(x-axis).
6. Practical values are compared with the theoretical values.

Result:

Comparison Table:

GRAPH SHEET HAS TO BE INSERTED HERE.

LOCUS DIAGRAMS OF RL & RC SERIES CIRCUITS.

Aim: To draw current locus diagrams for RL and RC series circuits with R variable and C variable.

Apparatus:

S.NO.	Name of the Apparatus	Range	Quantity
1	Rheostat	1500Ω /1.2A	1
2	Voltmeter	0-360V/600V(MI)	2
3	Ammeter	0-1A/2A(MI)	1
4	1-phase variac	230V/0-270V	1
5	Digital multimeter	-	1
6	Inductor	1H	1
7	Capacitor	4 µF, 8 µF, 10 µF, 12.5 µF, 20 µF	1 each
8	Connecting wires	-	As required

Theory:

In AC electrical circuits the magnitude and phase of the current vector depends upon the values of R, L&C when the applied voltage and frequency are kept constant. The path traced by the terminus (tip) of the current vector when the parameters R, L&C are varied is called the current Locus diagram.

Series RL circuit, with variable R:

Refer to the series RL circuit shown in the figure(a) below with constant X_L and varying R. The current I_L lags behind the applied voltage V by a phase angle $\Theta = \tan^{-1}(X_L/R)$ for a given value of R as shown in the figure (b) below. When R=0 we can see that the current is maximum equal to V/X_L and lies along the I axis with phase angle equal to 90^0. When R is increased from zero to infinity the current gradually reduces from V/X_L to 0 and phase angle also reduces from 90^0 to 0^0. As can be seen from the figure, the tip of the current vector traces the path of a semicircle with its diameter along the +ve I axis.
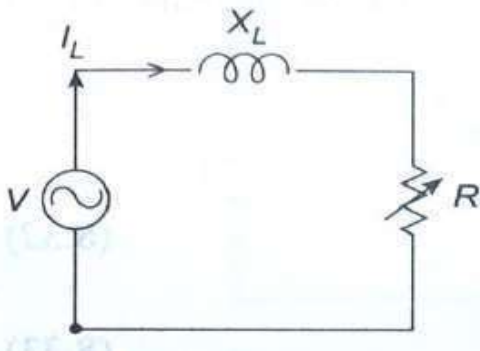
Figure(a): Series RL circuit with RVarying Resistance R   Figure(b): Locus of current vector I_L with variation of
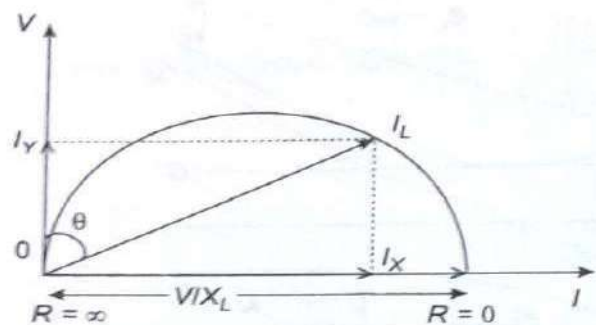
LOCUS DIAGRAMS OF RL & RC SERIES CIRCUITS.

I_L = V/Z
Sin Θ = XL/Z or Z = XL/ Sin Θ and
Cos Θ = R / Z
Therefore, IL = (V/XL) Sin Θ
For constant V and X_L the above expression for I_L is the polar equation of a circle with diameter
(V/XL) and center as (V/2XL, 0).

Series R C circuit:
(i)   Variable R.
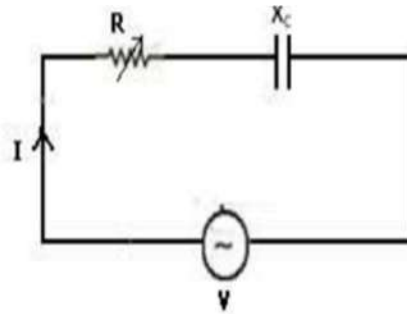
When R = 0 current is maximum and is given by $I_{max} = \frac{V}{X_c}$, which leads the voltage by 90^0 .Power factor is zero.

When R = ∞, the current is zero. The power factor is unity & $\emptyset$ = 0

For any other value of R the current leads the voltage by an angle $\emptyset = tan^{-1}\frac{X_c}{R}$

$\therefore$ The general expression for current is

$$I = \frac{V}{\to R^2 + X_L{}^2} = \frac{V}{Z}\frac{X_c}{X_c} = \frac{V}{X_c}\frac{X_c}{Z} = \frac{V}{X_c}\sin\emptyset$$

$\therefore \frac{V}{X_c}\sin\emptyset$ is the equation of a circle in the polar form, where $\frac{V}{X_c}$ is the diameter of the circle.
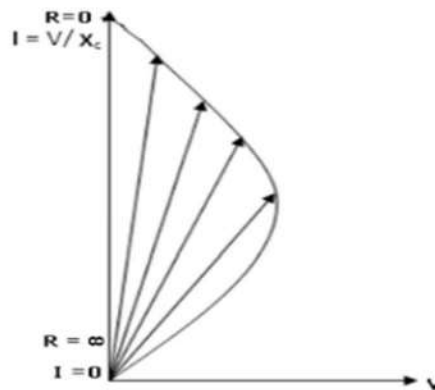
$\therefore$ Locus is a semi $-$ circle where radius is $\frac{R}{2X_c}$ & center is $\left(0, \frac{V}{2X_c}\right)$

LOCUS DIAGRAMS OF RL & RC SERIES CIRCUITS.

(ii)   Variable X_C:
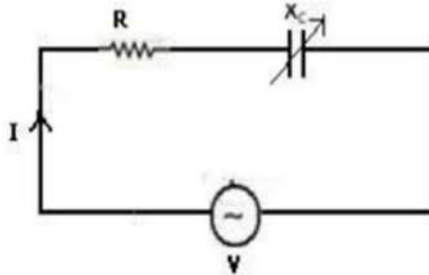
When $X_c = 0$, current is maximum & is given by $I_{max} = \dfrac{V}{R}$, which is in phase with V. Power factor is unity and $\emptyset = 0$

When $X_c = \infty$, the current is zero. Power factor is 0 & $\emptyset = 90^0$, for any other value of X_c , the current leads the voltage by an angle $\emptyset = tan^{-1}\dfrac{X_c}{R}$

The general equation for the current is

$$I = \frac{V}{Z} = \frac{V}{Z}\frac{R}{R} = \frac{V}{R}X\frac{R}{Z} = \frac{V}{R}\,cos\emptyset$$

The equation $I = \dfrac{V}{R}\,cos\emptyset$ is the equation of the circle in polar form, where $\dfrac{V}{R}$ is the diameter of the circle.
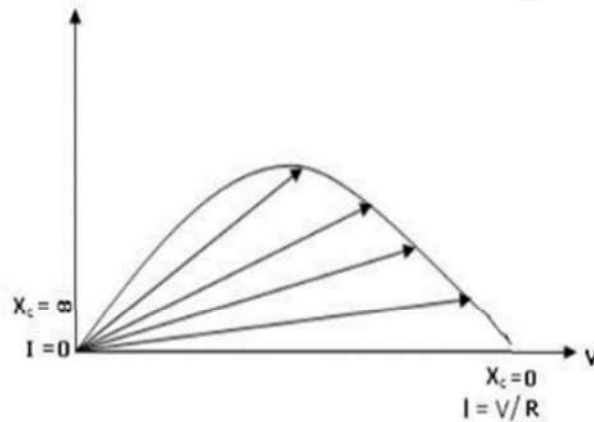
The locus is a circle of radius $\rightarrow\dfrac{V}{2R}$.   ,

II B.Tech-I Semester   Experiment No:4

II B.Tech-I Semester   Experiment No:4

LOCUS DIAGRAMS OF RL & RC SERIES CIRCUITS.

CIRCUIT DIAGRAMS:

Circuit (1): Series R L with R varying.
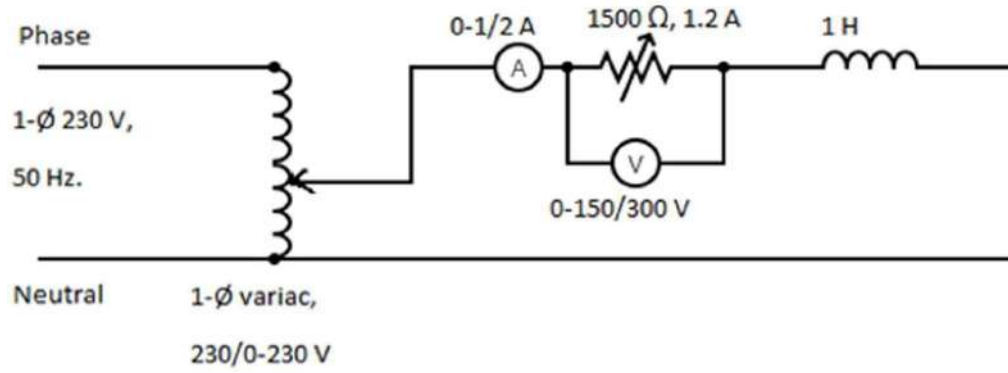
Tabular column for circuit-1: L = ………..H, $X_L = 2\pi f L =$ Ω

S.No	V (V)	I (A)	R (Ω)	$\emptyset = Tan^{-1}(X_L/R)$

II B.Tech-I Semester   Experiment No:4

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LOCUS DIAGRAMS OF RL & RC SERIES CIRCUITS.

Circuit (2): Series R C with R variable.
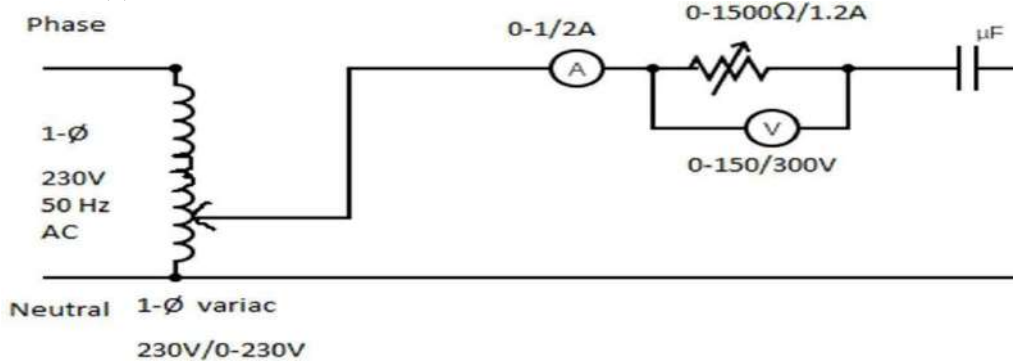
Tabular column for circuit (2): C = ………..F, $X_c = 1/2\pi f C =$ Ω

S.No	V (V)	I (A)	R (Ω)	Ø = Tan^{-1}(Xc/ R)

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LOCUS DIAGRAMS OF RL & RC SERIES CIRCUITS.

Circuit (3): Series R C with C variable:
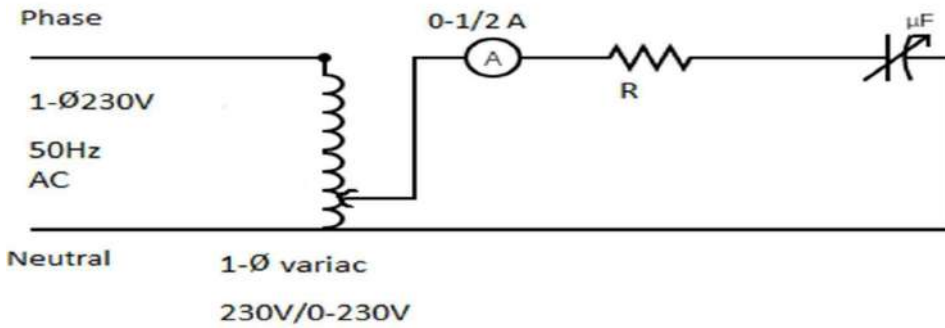
Tabular column for circuit (3):

S.No	V(volts)	I(amps)	X_c (Ω)	Ø = Tan^{-1}(Xc/ R)

II B.Tech-I Semester   Experiment No:4

LOCUS DIAGRAMS OF RL & RC SERIES CIRCUITS.

Model graph:

As shown in theory above.

Procedure:

RL circuit:
1. Connections are made as per the respective circuits.
2. Keep the rheostat in minimum position.
3. Output voltage of the variac is set to the value equivalent to the rated current of the inductor(0.4A).
4. Rheostat is varied from minimum to maximum and corresponding reading of ammeter and voltmeter are noted.
5. Current locus is drawn between voltage(x-axis) and current(y-axis) and angle is taken with respect to voltage.

RC circuit:
1. Connections are made as per the respective circuits.
2. Keep the rheostat in minimum position.
3. Output voltage of the variac is set to the rated voltage of capacitor .
4. Rheostat is varied from minimum to maximum and corresponding reading of ammeter and voltmeter are noted.
5. Current locus is drawn between voltage(x-axis) and current(y-axis) and angle is taken with respect to voltage.

Result:

Note: Graphs need to be attached.

II   B.Tech **I** Semester   Experiment No: 5

Generation of various signals and sequences (unit Impulse, Step, Square, saw tooth, Triangular, Sinusoidal, Ramp) and operations on signals and sequences (Addition, Multiplication, Scaling, Shifting, Folding, Computation of Energy, and Average Power) using software.

(a)Generation of various signals and sequences.

Aim: Generate various signals and sequences (Periodic and aperiodic) such as Unit Impulse, Unit Step, Square, Saw tooth, Triangular, Sinusoidal, Ramp, Sinc.

Software Required: MATLAB software.

Theory:

Unit impulse signal: The Ideal impulse function is a function that is zero everywhere but infinitely high at the origin. However, the *area* of the impulse is finite. It is defined as

$$\delta(t) = 1 \qquad at \; t=0$$

$$=0 \qquad other \; wise$$

Unit step signal: The unit step function, also known as the Heaviside function, is defined as such:

$$u(t) = 0 \qquad if \; t<0$$

$$=1 \qquad if \; t>=0$$

Sinc signal: The Sinc function is defined in the following manner:

$$\sin c(x) = \frac{\sin \pi x}{\pi x} \quad if \; x \neq 0 \; and$$

$$Sin \; c(x) = 1 \; at \; x=0$$

Following are some of the MATLAB functions used to plot the graphs.

Plot(Y): Plots the columns of Y versus their index if Y is a real number.

Plot(x,y): Plots all lines defined by vector X versus vector Y pairs.

Stem(x,y):

A two-dimensional stem plot displays data as lines extending from a baseline along the x-axis. A circle (the default) or other marker whose y-position represents the data value terminates each stem.

Subplot(m,n)

subplot divides the current figure into rectangular panes that are numbered row wise.

Subplot(m,n,p)

subplot(m,n,p) breaks the figure window into an m-by-n matrix

1

II   B.Tech **I** Semester   Experiment No: 5

of small axes. P is a number that specifies the position of the plane (subplot).

PROGRAM:

```
% Generation of signals and sequences %
clc;
%generation of unit impulse signal%
t1= -1:0.02:1
y1= (t1==0);
Subplot (2,2,1);
Plot (t1,y1);
axis ([-1 1 -0.5 1.5]);
xlabel ('time');
ylabel ('amplitude');
title ('unit impulse signal');
%generation of impulse sequence%
subplot(2,2,2);
stem(t1,y1);
axis([-1 1 -0.5 1.5]);
xlabel('n');
ylabel('amplitude');
title('unit impulse sequence');
%generation of unit step signal%
t2=-5:0.1:5;
y2=(t2>=0);
 subplot(2,2,3);
plot(t2,y2);
axis([-5 5 -0.5 1.5]);
xlabel('time');
ylabel('amplitude');
title('unit step signal');
%generation of unit step sequence%
subplot(2,2,4);
```

```
stem(t2,y2);


axis([-5  5  -0.5 1.5]);

xlabel('n');

ylabel('amplitude');

title('unit step sequence');
%generation of square wave signal%
t=0:0.2:10;
 y3=square(t);

figure;

subplot(2,2,1);

plot(t,y3);

axis([0 10 -2 2]);

xlabel('time');

ylabel('amplitude');

title('square wave signal');
%generation of square wave sequence%
subplot(2,2,2);

stem(t,y3);

axis([0 10 -2 2]);

xlabel('n');

ylabel('amplitude');

title('square wave sequence');
%generation of saw tooth signal%
y4=sawtooth(t);

subplot(2,2,3);

plot(t,y4);

axis([0 10 -2 2]);

xlabel('time');

ylabel('amplitude');

title('sawtooth wave signal');
```
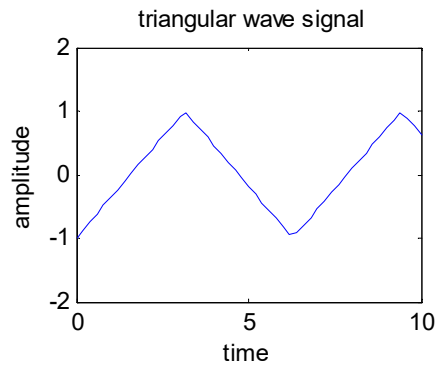
```
%generation of sawtooth sequence%
subplot(2,2,4);
stem(t,y4);
axis([0 10 -2 2]);
xlabel('n');
ylabel('amplitude');
title('sawtooth wave sequence');
%generation of triangular wave signal%
y5=sawtooth(t,0.5);
figure;
subplot(2,2,1);
plot(t,y5);
axis([0 10 -2 2]);
xlabel('time');
ylabel('amplitude');
title(' triangular wave signal');
%generation of triangular wave sequence%
subplot(2,2,2);
stem(t,y5);
axis([0 10 -2 2]);
xlabel('n');
ylabel('amplitude');
title('triangular wave sequence');
%generation of sinsoidal wave signal%
y6=sin(t);
subplot(2,2,3);
plot(t,y6);
axis([0 10 -2 2]);
xlabel('time');
ylabel('amplitude');
title(' sinsoidal wave signal');
```

II   B.Tech **I** Semester   Experiment No: 5

```
%generation of sin wave sequence%
subplot(2,2,4);
stem(t,y6);
axis([0 10 -2 2]);
xlabel('n');
ylabel('amplitude');
title('sin wave sequence');
%generation of ramp signal%
y7=t;
figure;
subplot(2,2,1);
plot(t,y7);
xlabel('time');
ylabel('amplitude');
title('ramp signal');
%generation of ramp sequence%
subplot(2,2,2);
stem(t,y7);
xlabel('n');
ylabel('amplitude');
title('ramp sequence');
%generation of sinc signal%
t3=linspace(-5,5);
y8=sinc(t3);
subplot(2,2,3);
plot(t3,y8);
xlabel('time');
ylabel('amplitude');
title(' sinc signal');



%generation of sinc sequence%
```

II   B.Tech **I** Semester   Experiment No: 5

subplot(2,2,4);

stem(y8);

xlabel('n');

ylabel('amplitude');

title('sinc sequence');

Output: (Expected waveforms)
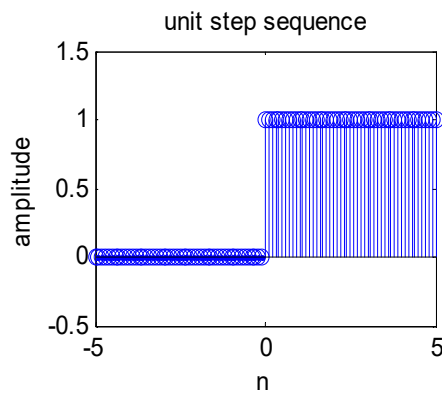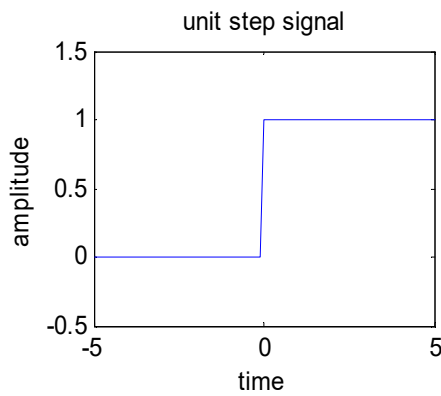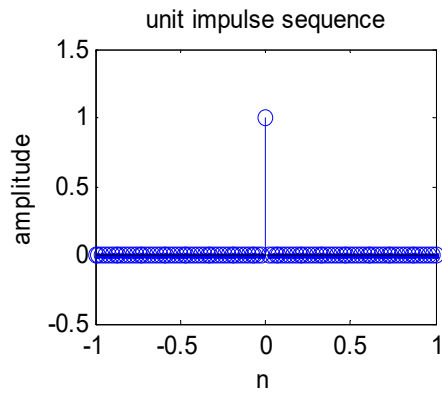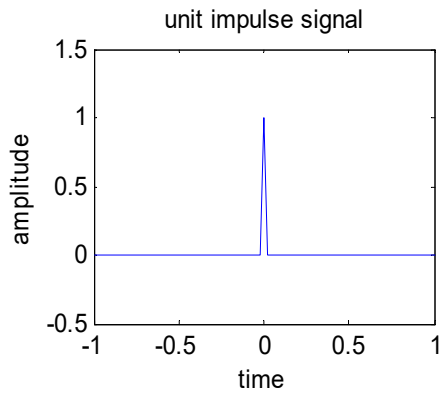
square wave signal

square wave sequence

sawtooth wave signal

sawtooth wave sequence

triangular wave signal

triangular wave sequence

sinsoidal wave signal

sin wave sequence

ramp signal

ramp sequence

sinc signal

sinc sequence
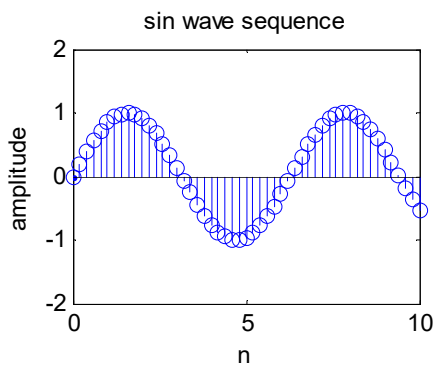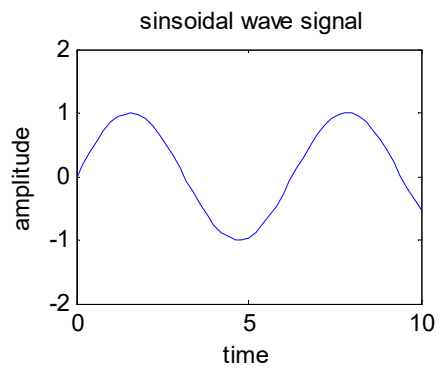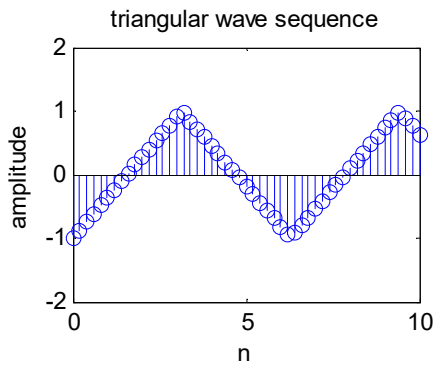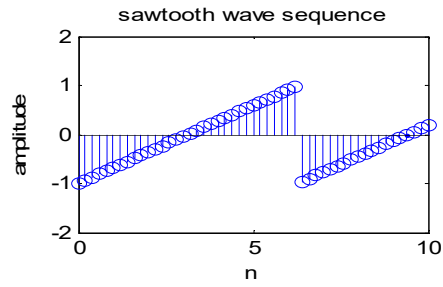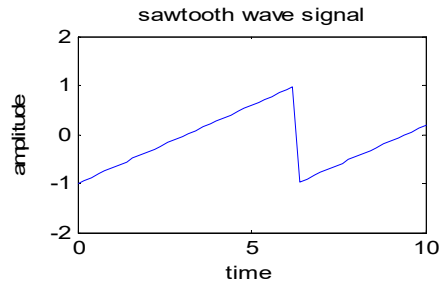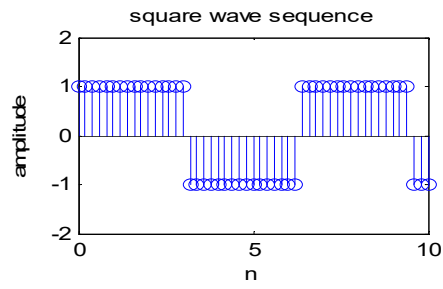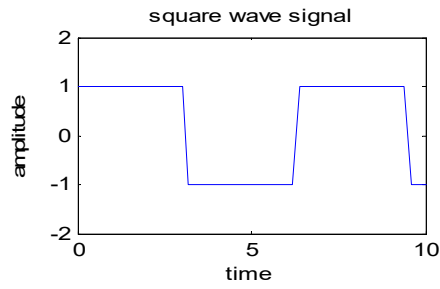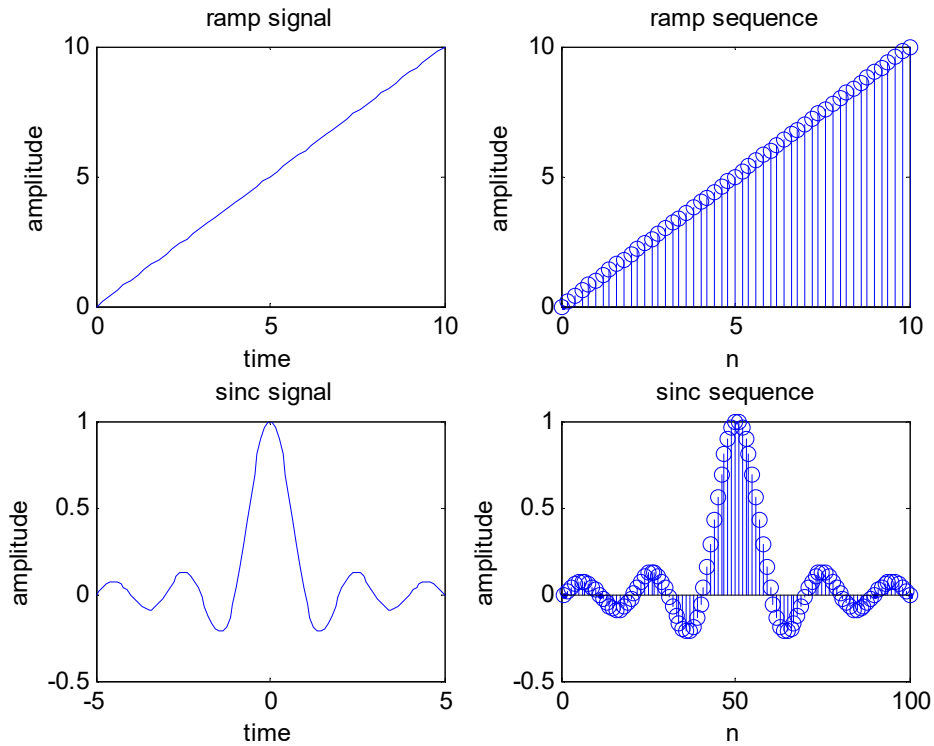
(b) Basic Operations on Signals and sequences

Aim:

Perform the operations on signals and sequences such as addition, multiplication, scaling, shifting, folding and also compute energy and power.

Software Required: MATLAB software.

Theory:

Addition: Any two signals can be added to produce a third signal,

z (t) = x (t) + y (t)

Multiplication :

Multiplication of two signals can be obtained by multiplying their values at every instant.

z(t) = x (t)* y (t)

Time reversal/Folding:

Time reversal of a signal x(t) can be obtained by folding the signal about t=0.

z(t)= x(-t)

if x(t) is original signal then z(t) is folded signal.

Signal Amplification/Scaling :

Y(n)=a.x(n)   if   a < 1 ; attenuation

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a >1; amplification

Time shifting: The time shifting of x(n) obtained by delay or advance the signal in time by

using y(n)=x(n+k)

If k is a positive number, y(n) shifted to the right i e the shifting delays the signal.

If k is a negative number, y(n) it gets shifted left. Signal Shifting advances the signal.

Energy:

$$E(n) = \sum_{-N}^{N} |x(n)|^2$$

Average power

$$P(n) = \frac{1}{N} \sum_{0}^{N} |x(n)|^2$$

PROGRAM:

```
clc;
% Generating two input signals%
t=0:.01:1;
x1=sin(2*pi*4*t);
x2=sin(2*pi*8*t);
subplot(2,2,1);
plot(t,x1);
xlabel('time');
ylabel('amplitude');
title('input signal 1');
subplot(2,2,2);
plot(t,x2);
xlabel('time');
ylabel('amplitude');
title('input signal 2');

 % Addition of signals%
y1=x1+x2;
subplot(2,2,3);
plot(t,y1);
xlabel('time');
```

```matlab
ylabel('amplitude');

title('addition of two signals');
% Multiplication of signals%
y2=x1.*x2;

subplot(2,2,4);

plot(t,y2);

xlabel('time');

ylabel('amplitude');

title('multiplication of two signals');



% Scaling of a signal%
A=2;

y3=A*x1;

figure;

subplot(2,2,1);

plot(t,x1);

xlabel('time');

ylabel('amplitude');

title('input signal')

subplot(2,2,2);

plot(t,y3);

xlabel('time');

ylabel('amplitude');

title('amplified input signal');
% Folding of a signal%
h=length(x1);

nx=0:h-1;

subplot(2,2,3);

plot(nx,x1);

xlabel('nx');

ylabel('amplitude');

title('input signal')
```

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```
y4=fliplr(x1);

nf=-fliplr(nx);

subplot(2,2,4);

plot(nf,y4);

xlabel('nf');

ylabel('amplitude');

title('folded signal');

%Shifting of a signal%

figure;

subplot(3,1,1);

plot(t,x1);

xlabel('time t');

ylabel('amplitude');

title('input signal');

subplot(3,1,2);

plot(t+2,x1);

xlabel('t+2');

ylabel('amplitude');

title('right shifted signal');

subplot(3,1,3);

plot(t-2,x1);

xlabel('t-2');

ylabel('amplitude');

title('left shifted signal');

%Operations on sequences%

n1=1:1:9;

s1=[1 2 3 0 5 8 0 2 4];

figure;

subplot(2,2,1);

stem(n1,s1);

xlabel('n1');

ylabel('amplitude');

title('input sequence1');
```

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```
s2=[1 1 2 4 6 0 5 3 6];

subplot(2,2,2);

stem(n1,s2);

xlabel('n2');

ylabel('amplitude');

title('input sequence2');
```

% Addition of sequences

```
s3=s1+s2;

subplot(2,2,3);

stem(n1,s3);

xlabel('n1');

ylabel('amplitude');

title('sum of two sequences');
```

 % Multiplication of sequences

```
s4=s1.*s2;

subplot(2,2,4);

stem(n1,s4);

xlabel('n1');

ylabel('amplitude');

title('product of two sequences');
```

% Program for energy of a sequence

```
z1=[ 1  3  2  4  1  ];

e1=sum(abs(z1).^2);

disp('energy of given sequence is');e1
```

 % Program for energy of a signal

```
t=0:1:10

z2=cos(2*pi*50*t).^2;

e2=sum(abs(z2).^2);

disp('energy of given signal is'); e2
```

 % program for power of a sequence

```
p1= (sum(abs(z1).^2))/length(z1);

disp('power of given sequence is');p1
```

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% program for power of a signal

p2=(sum(abs(z2).^2))/length(z2);

disp('power of given signal is');p2
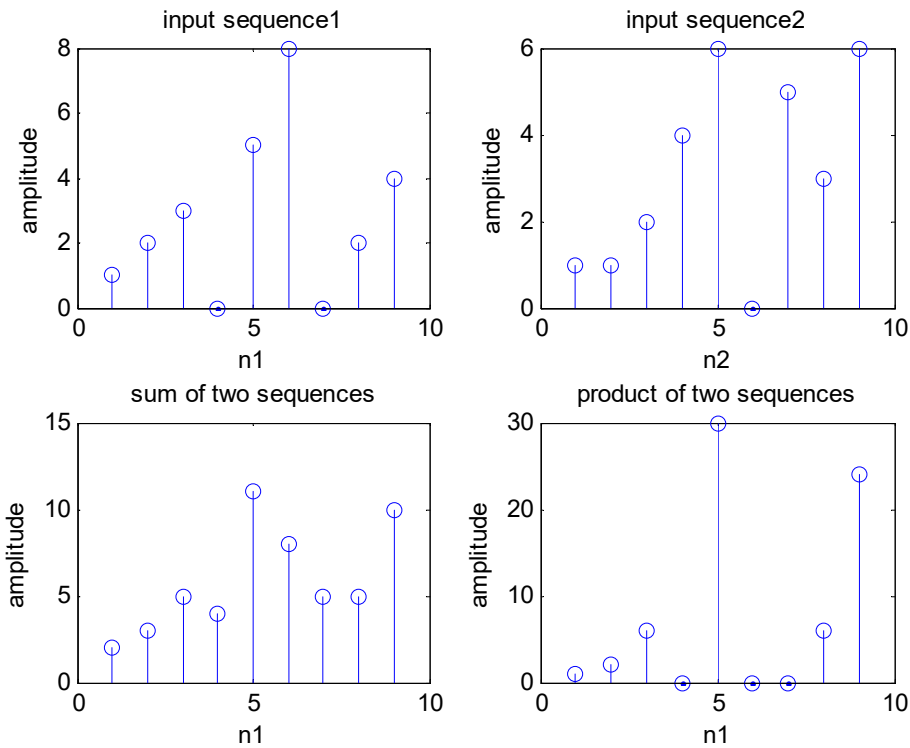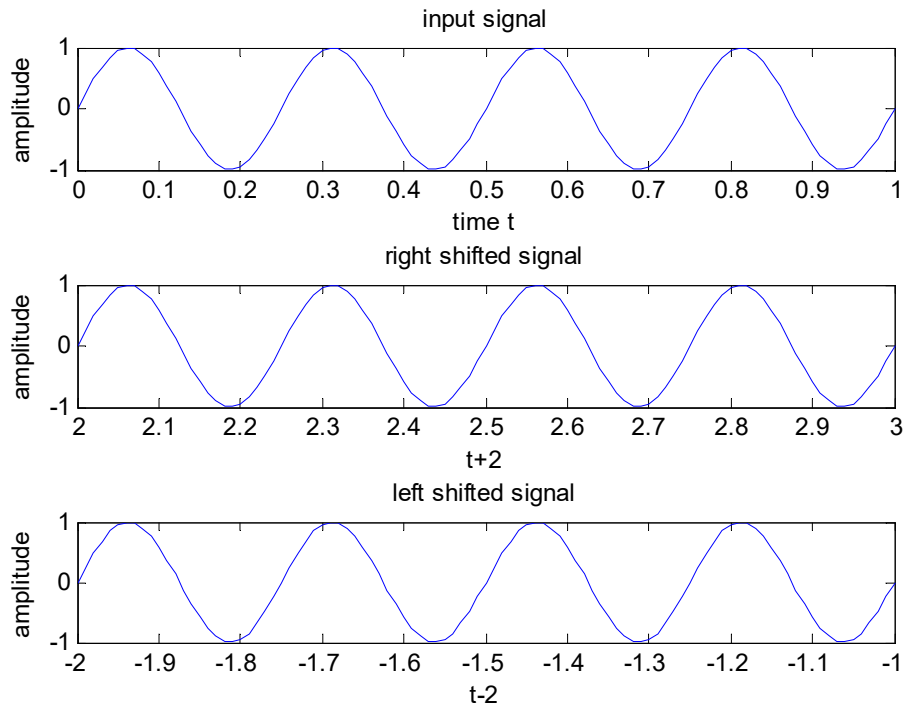
Outputs:
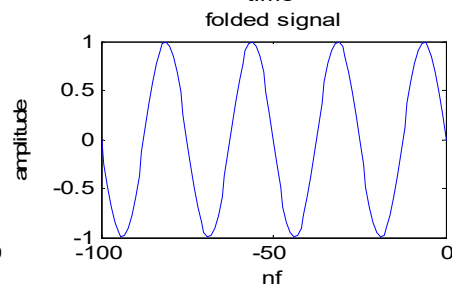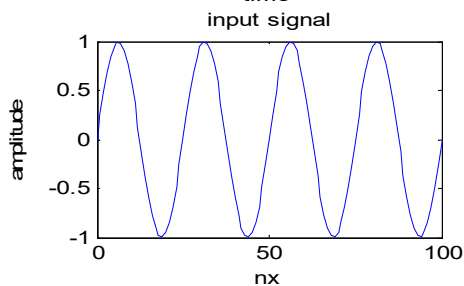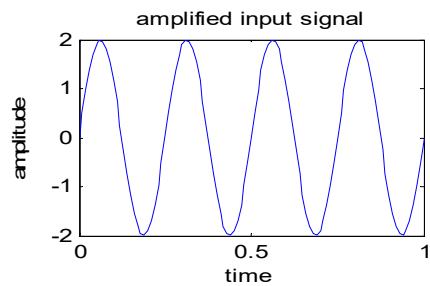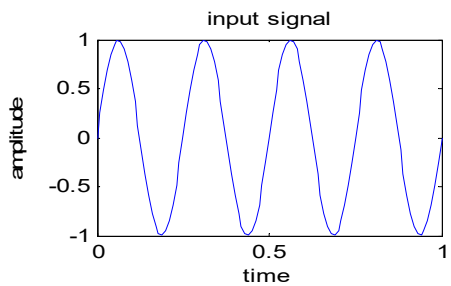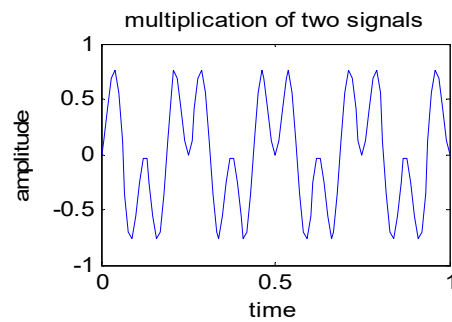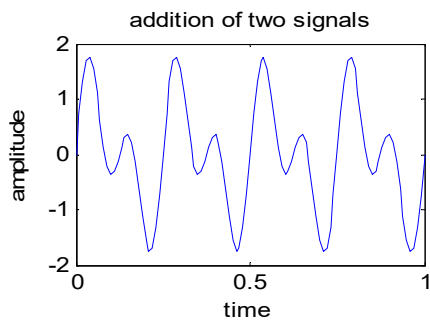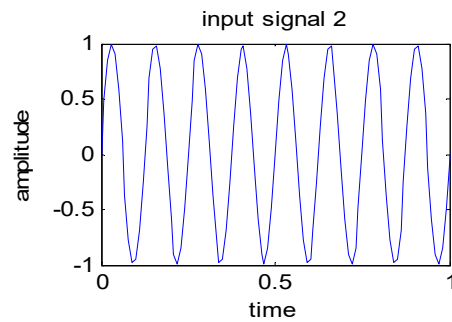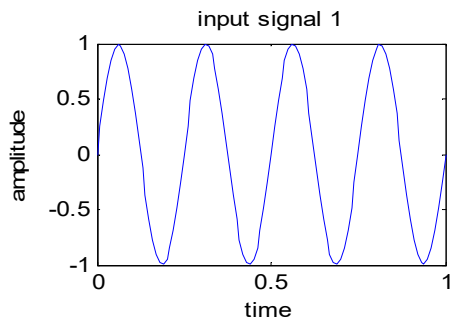
input signal

right shifted signal

left shifted signal

input sequence1

input sequence2

sum of two sequences

product of two sequences

Result:

Corresponding graphs have to be inserted.

SIMULATION OF TRANSIENT RESPONSE OF RL, RC & RLC CIRCUITS

AIM: To find the time response of current through series RL, RC & RLC circuit for step input voltages.

SOFTWARE REQUIRED: MATLAB-SIMULINK.

THEORY:
Series RLC circuit:
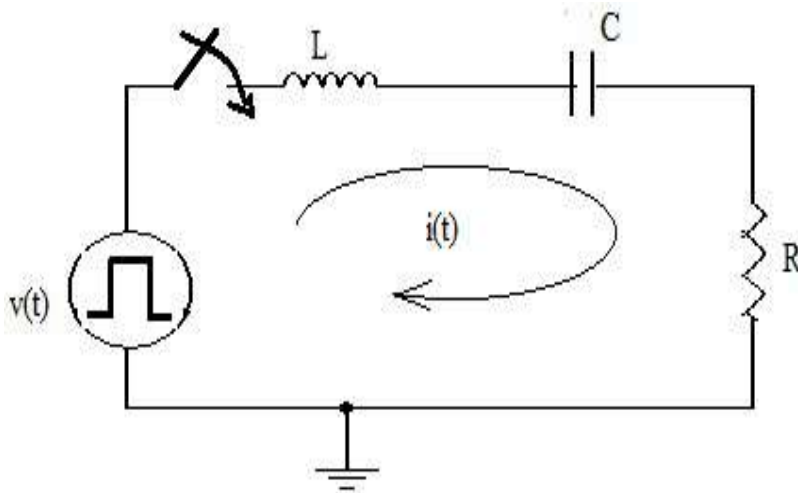
Fig 1.a

The series RLC circuit is shown in fig1.a.. v(t) is the voltage source. The relation between the source voltage and current is given by equation

$$Ri(t) + L\frac{di}{dt} + \frac{1}{C}\int idt = v(t)$$

This is a linear differential equation. Taking Laplace Transformer will get

$$(R + LS + \frac{1}{CS})\,I\,(S) = V\,(S)$$

$$I(s) = V(s) / [R + SL + 1/SC]$$

$$= V(s) * S/L / \{S^2 + SR/L + 1/LC\}$$

$$= V(s) * S/L / [(S-\propto1)*(S-\propto2)] \quad ;$$

$$\alpha1 = -\frac{R}{2L} + \sqrt{\left(\frac{R}{2L}\right)^2 - \frac{1}{LC}}$$

$$\alpha2 = -\frac{R}{2L} - \sqrt{\left(\frac{R}{2L}\right)^2 - \frac{1}{LC}}$$

$$\alpha1 = -\sigma + j\omega_d$$

$$\alpha2 = -\sigma - j\omega_d$$

The condition for critical resistance R_c is

$$\left(\frac{R}{2L}\right)^2 = \frac{1}{LC} \qquad ; \qquad R_c = 2.\sqrt{\frac{L}{C}}$$

If $R < R_c$, Under Damped & If $R > R_c$, Over Damped

Current through the RLC circuit:

i)   Overdamped case:

$$I(t) = A_1 e^{-\sigma 1 t} + A_2 e^{-\sigma 2 t}$$

ii)   Critically damped case:

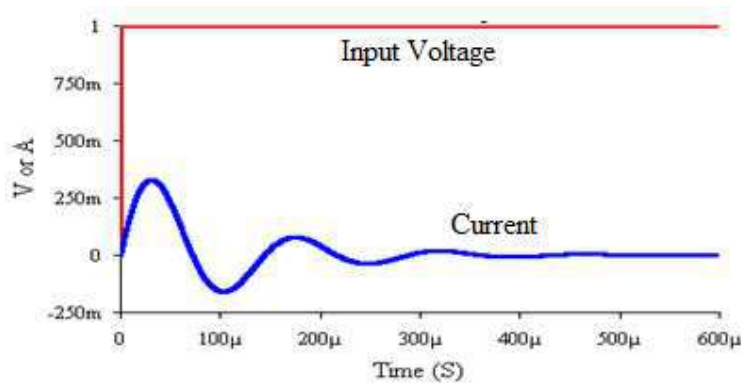$$I(t) = (A_1 + A_2.t)e^{-\sigma t}$$

iii)   Under damped case:

$$I(t) = e^{-\sigma t}(A_1 \cos(\omega_d.t) + A_2 \sin(\omega_d.t))$$

Values of Parameters to be inserted in Circuit-Diagrams:

DC Input voltage: - V=1,

L=50μH, C= 10μF & R= 1,4.472 & 8 ohms

Input Voltage &Current Waveforms:

Transient Response of RLC circuit
Fig 1.b

SAMPLE CALCULATIONS:

For V=1 , L=50μH, C= 10μF & R= 1 ohms

R_c=2*sqrt(50e-6/10e-6) = 4.472 Ω, R=1,

$\sigma = \frac{R}{2L} = 1/(2*50e\text{-}6) = 1e4,$

$$\omega d = \sqrt{\left(\frac{R}{2L}\right)^2 - \frac{1}{LC}} = \sqrt{(1e4 * 1e4 \ - 1/(50e - 6 * 10e - 6))} = j\ 43589;$$

Series RL Circuit:

Consider a circuit consisting of a resistance and inductance as shown in figure 2.a.
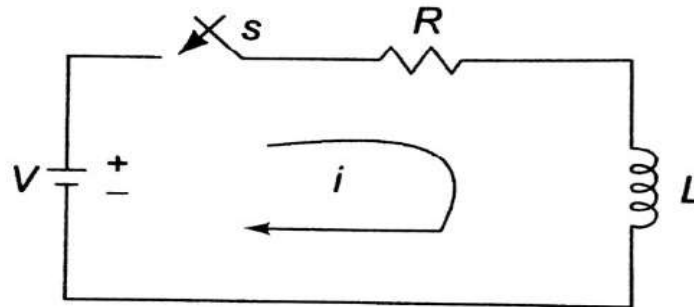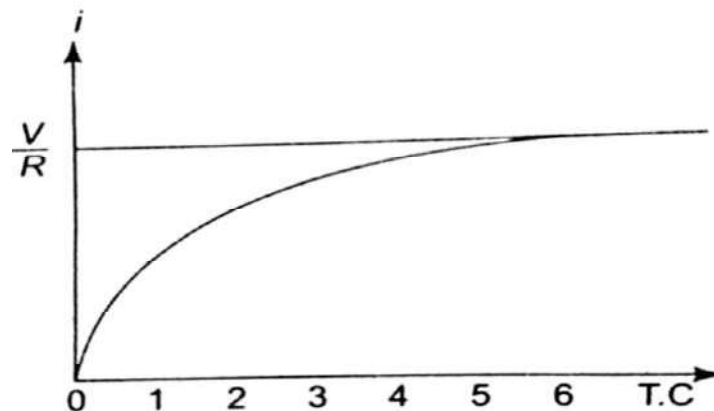

Fig 2.a

The inductor in the circuit is initially uncharged and is in series with the resistor. when the switch is closed, the complete solution for the current is given below

$$I = \frac{V}{R}\left(1 - \exp\left(-\frac{R}{L}t\right)\right)$$

Current response of RL circuit is shown in figure 2.b

Fig 2.b

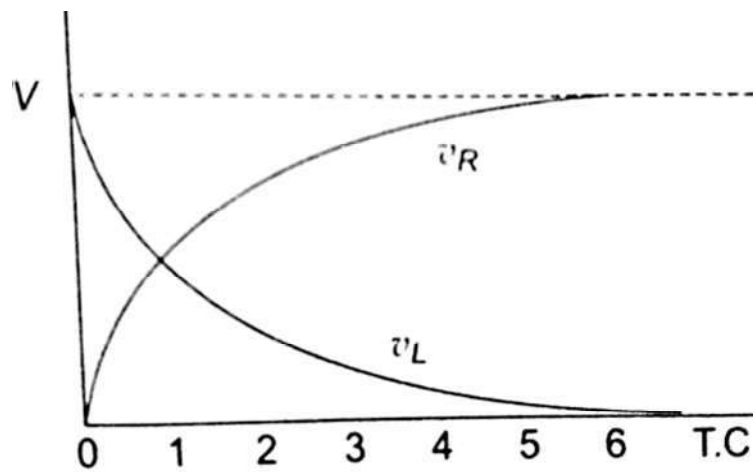The voltage across resistor and inductor are shown in figure 2.c

Fig 2.c

Step Response of RC circuit:

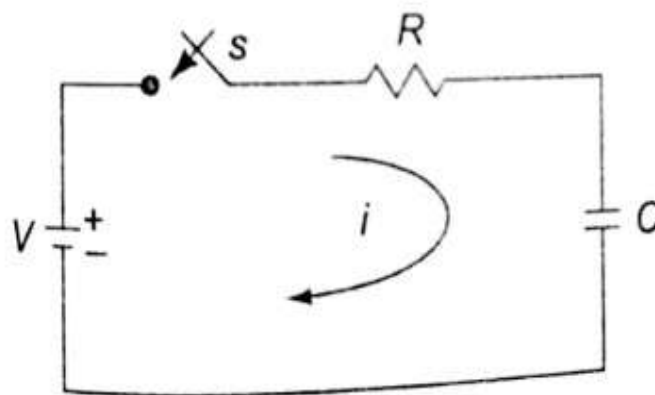Consider a circuit consisting of resistance and capacitance as shown in below figure3.a

Fig 3.a

The capacitor in the circuit is initially uncharged, and is in series with a resistor. When the switch is closed at t=0, the complete solution of the current is given by

$$I = \frac{V}{R}\left(\left(e - \left(\frac{t}{RC}\right)\right)\right)$$

Current and voltage responses of RC circuit is shown in figure3.b
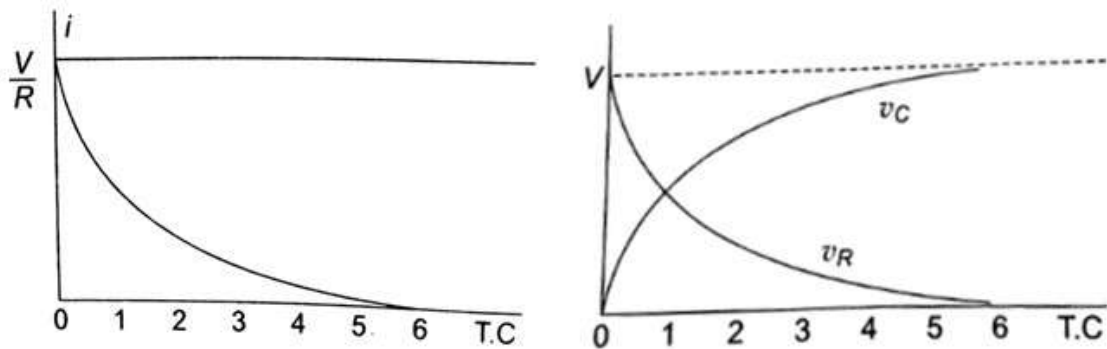
Fig 3.b

SIMULINK DIAGRAMS:
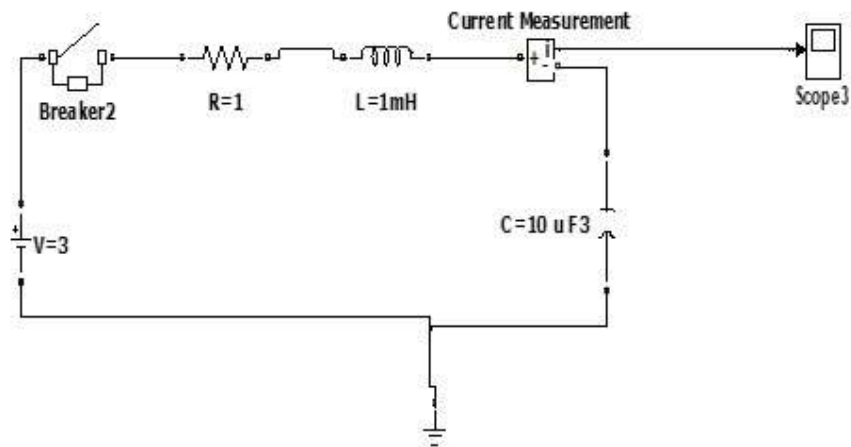
Figure4.1. Simulink diagram for step response of RLC circuit
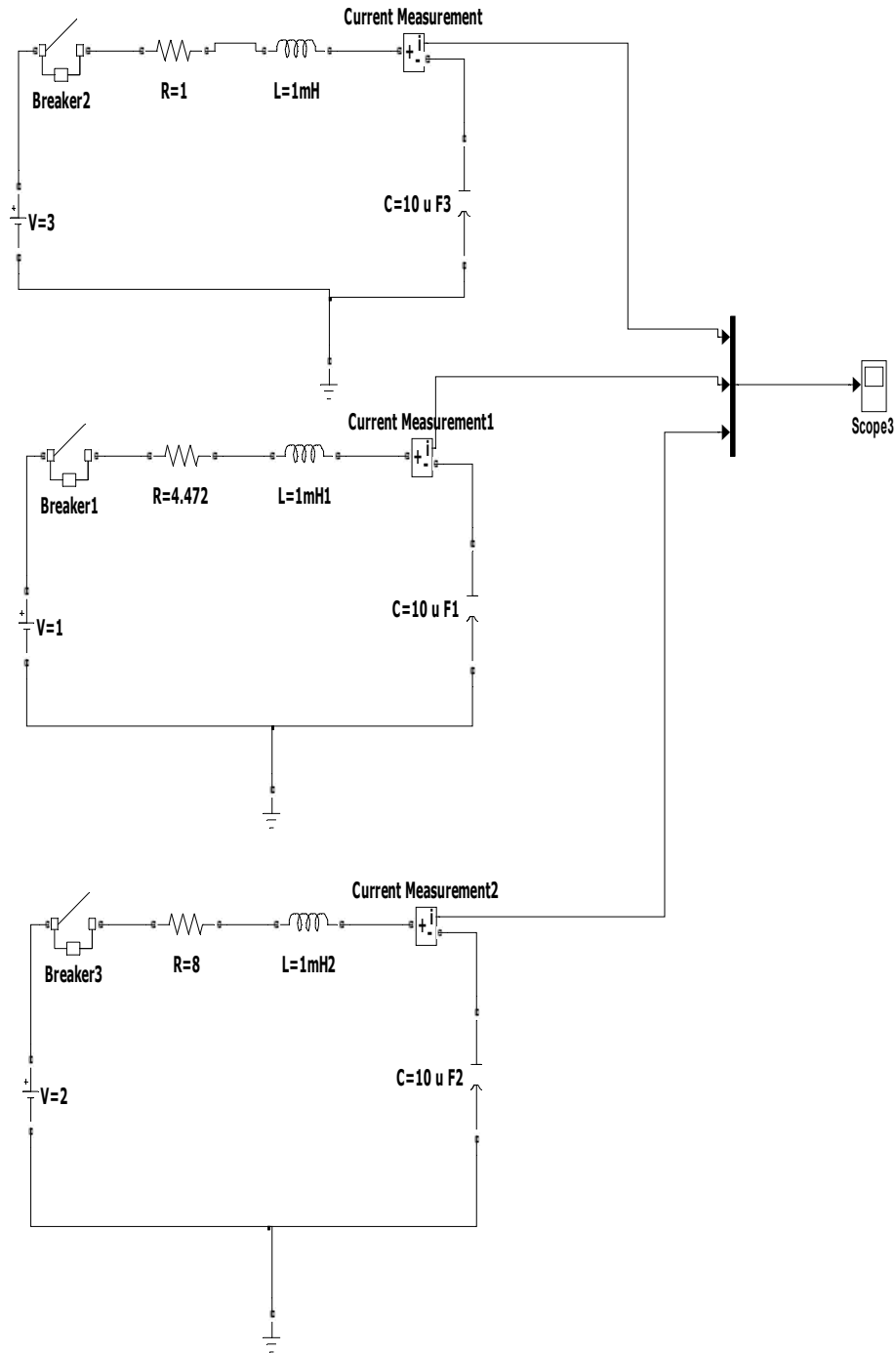
Figure4.2. Simulink diagram for analysis of step response of RLC circuit for different damping cases
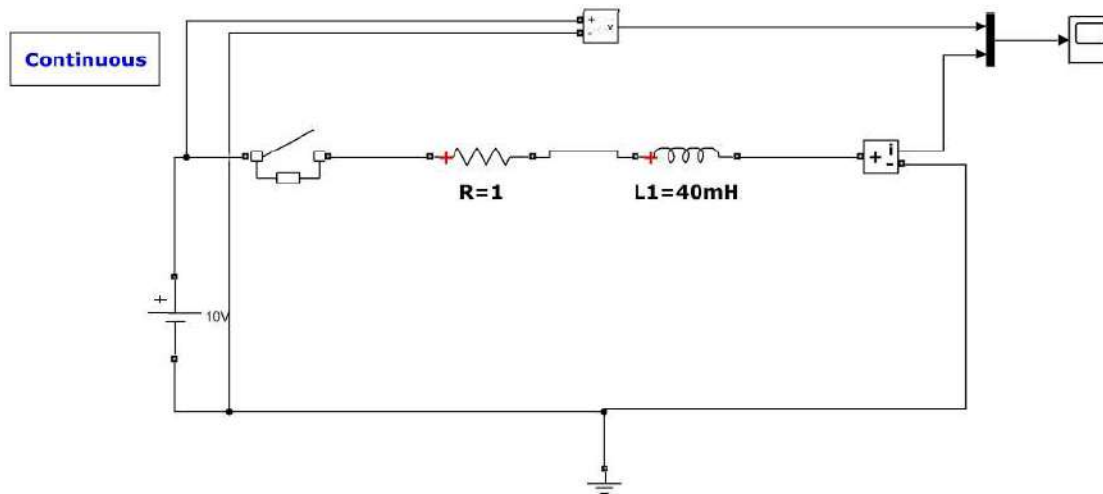
Figure4.3. Simulink diagram for step response of RL circuit
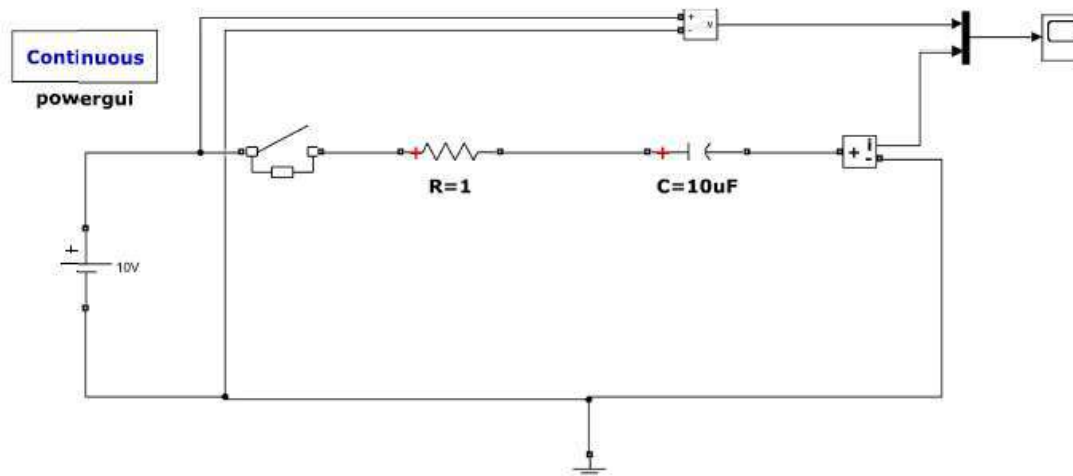
Figure4.4. Simulink diagram for step response of RC circuit

RESULT:

Graphs need to be attached.

MEASUREMENT OF 3-PHASE CIRCUIT USING 2 WATTMETER METHOD

Aim: To measure power of a 3-phase circuit using two-wattmeter method for three-phase star and delta connected balanced loads. Calculation of power factor for respective loads.

Apparatus:

S.NO.	Name of the Apparatus	Range and type	Quantity
1	Ammeter	0-10A (MI)	2
2	Voltmeter	0-600V(MI)	1
3	Wattmeter	600V/10A, UPF.	2
4	3ϕ Resistive load		1
5	3ϕ Inductive load		1
6'	LCR meter		1
7.	Digital multi meter		1
8.	Triple pole single throw switch(TPST)		1
9.	Connecting Wires		As required.

Theory:

This method is commonly used for the power measurement in the 3 phase circuits. Here as namesuggests, only two wattmeters are used. The current coils of the two wattmeters are connected inseries on any two lines. The corresponding pressure coils are connected between these lines and the third line on which no wattmeter is connected.

The two wattmeter method is used for the power measurement in the 3-phase systems,irrespective of whether the load is balanced or unbalanced, star or delta connected.

Total Power = $W_1 + W_2$

As it is a balance condition, $V_a = V_b = V_c =$

phase voltageThree Phase power = $3V_{ph}I_{ph}cos\Phi$

As it is a balance condition, $V_a = V_b = V_c =$

phase voltage$I_a = I_b = I_c =$ phase current

For resistive load cos ϕ = 1.

So, Three phase power = $3V_{ph}I_{ph}$

$W_1 = V_{AB}I_A \cos(30 - \Phi) = \sqrt{3}V_{ph}I_{ph}\cos$

$(30 - \Phi)W_2 = V_{BC}I_C \cos(30 \mp \Phi) =$

$\sqrt{3}V_{ph}I_{ph}\cos (30 + \Phi)$

$W_1 + W_2 = \sqrt{3}V_{ph}I_{ph}[2\cos30^0\cos\Phi] = 3V_{ph}I_{ph}\cos\Phi = \sqrt{3}V_LI_L\cos\Phi$

The above equation shows that the sum of the two wattmeter readings gives the total power consumed in the three-phase balanced system. Load power factor angle can be calculated from the measurement of W_1 and W_2.

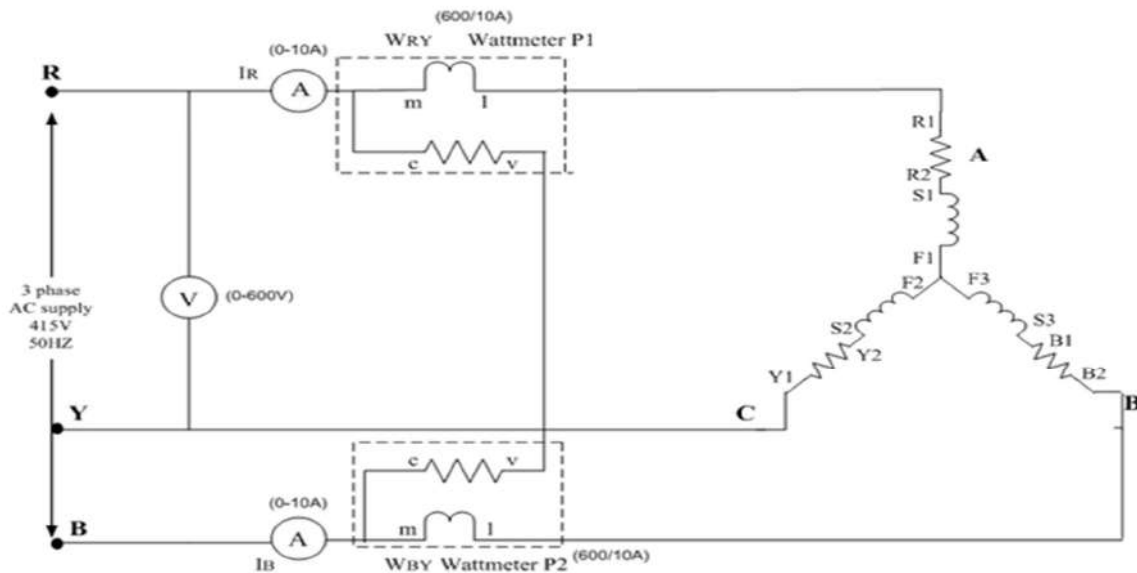$$\tan\Phi = \sqrt{3}\frac{W_1 - W_2}{W_1 + W_2}$$

CIRCUIT DIAGRAM:

Figure 1: Circuit diagram for star connected balanced load.

Figure 2: Circuit diagram for delta connected balanced load.

Observations:

Star connected balanced load

S.No	V_1 (V)	I_R (A)	I_B (A)	P_1 (W)	P_2 (W)	$P_T=P_1+P_2$ (W)

Delta connected balanced load

S.No	V_1 (V)	I_R (A)	I_B (A)	P_1 (W)	P_2 (W)	$P_T=P_1+P_2$ (W)

Procedure:

1. Connect the circuit as shown in the circuit diagram for star connected load.
2. Switch ON the supply.
3. Note the readings of voltmeter, ammeter and wattmeter at no load condition and gradually increase the load.
4. Switch OFF the loads and then supply.
5. Connect the circuit as shown in the circuit diagram for delta connected load.
6. Switch ON the supply.
7. Note the readings of voltmeter, ammeter and wattmeter at no load condition and gradually increase the load.
8. Switch OFF the loads and then supply.

Result:

II B.Tech,I – Semester   Experiment No. 8(a) &(b)

TIME RESPONSE OF R-L & R-C SERIES CIRCUIT

AIM: -

To study the time response of current of R-L & R-C network for D.C input voltage and find the time constant both theoretically and practically.

APPARATUS:-

1. Resistor -1 kilo ohm.
2. Capacitor - 0.01 micro farad (μF).
3. Inductor - 10 milli henery (mH).
4. Function Generator.
5. Cathode Ray Oscilloscope. (CRO)
6. CRO Probes.
7. Patch chords.

THEORY: -

Time response of R-L series circuit:

R-L series circuit is a circuit that contains a pure resistance of R ohms connected in series with a coil having pure inductance of L Henry is known as R-L series circuit.

Applying KVL to a simple RL series circuit, with a current 'i' amperes flowing through it. The following will be the set of equations,
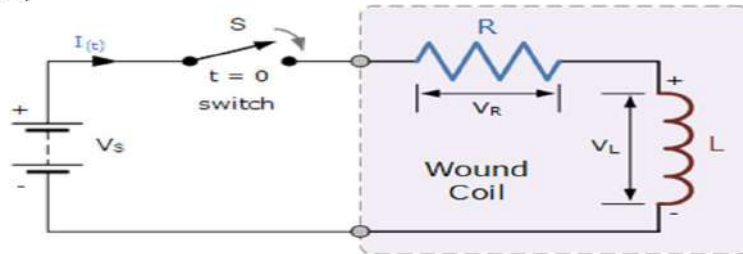
The above RL series circuit is connected across a constant voltage source, (the battery) and a switch. Assume that the switch, S is open until it is closed at a time t = 0, and then remains permanently closed producing a "step response" type voltage input. The current, i begins to flow through the circuit but does not rise rapidly to its maximum value of Imax as determined by the ratio of V / R (Ohms Law).
This limiting factor is due to the presence of the self induced emf within the inductor as a result of the growth of magnetic flux, (Lenz's Law). After a time the voltage source neutralizes the effect of the self induced emf, the current flow becomes constant and the induced current and field are reduced to zero.

We can use Kirchhoff's Voltage Law, (KVL) to define the individual voltage drops that exist around the circuit and then hopefully use it to give us an expression for the flow of current.

Time response of series RL and RC circuit

II B.Tech,I – Semester   Experiment No. 8(a) &(b)

Kirchhoff's voltage law (KVL) gives us:

$$V_{(t)} - (V_R + V_L) = 0$$

The voltage drop across the resistor, R is I*R (Ohms Law).

$$V_R = I \times R$$

The voltage drop across the inductor, L is by now our familiar expression L(di/dt)

$$V_L = L\frac{di}{dt}$$

Then the final expression for the individual voltage drops around the LR series circuit can be given as:

$$V_{(t)} = I \times R + L\frac{di}{dt}$$

$$V = IR + L\frac{di}{dt}$$

$$\frac{V}{R} = i + \frac{L}{R}\frac{di}{dt}$$

$$\frac{V}{R} - i = \frac{L}{R}\frac{di}{dt}$$

$$\frac{R}{L}dt = \frac{di}{\frac{V}{R} - i}$$

Integrating both sides,

$$\int \frac{R}{L}dt = \int \frac{di}{\frac{V}{R} - i}$$

$$\rightarrow \frac{R}{R}t = -\ln\left[\frac{V}{R} - i\right] + k'$$

k'= integration constant.

To find k':
At t = 0, i = I₀ = 0

$$\ln\left[\frac{V}{R}\right] = k'$$

from initial conditions.

$$\frac{Rt}{L} = -\ln\left[\frac{V}{R} - i\right] + \ln\left[\frac{V}{R}\right]$$

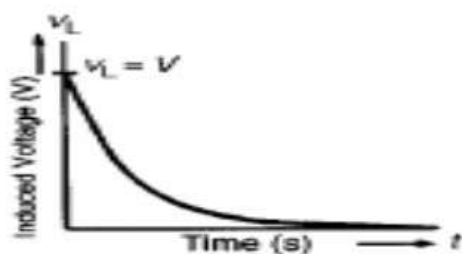$$\frac{R}{L}t = \ln\left[\frac{\frac{V}{R}}{\frac{V}{R} - i}\right]$$

Take anti log

$$e^{\frac{R}{L}t} = \frac{\frac{V}{R}}{\frac{V}{R} - i}$$
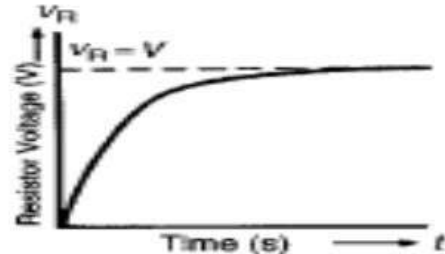
$$\frac{V}{R} - i = \frac{V}{R}e^{\frac{-R}{L}t}$$

$$i = \frac{V}{R}\left[1 - e^{\frac{-R}{L}t}\right]$$

Term V/R = steady state current

$$\frac{-V}{R}e^{-\frac{R}{L}t} = \text{Transient part of solution of current.}$$

(a) Induced voltage transient   (b) Resistor voltage transient
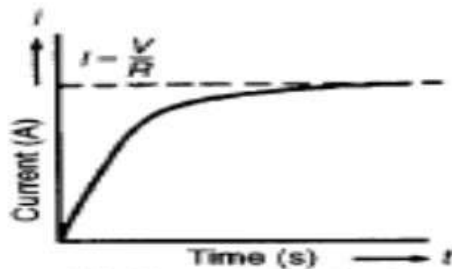
(c) Current transient

We can see that the voltage drop across the resistor depends upon the current, i, while the voltage drop across the inductor depends upon the rate of change of the current, di/dt. When the current is equal to zero, (i = 0) at time t = 0 the above expression, which is also a first order differential equation, can be rewritten to give the value of the current at any instant of time as:Expression for the Current in an LR Series Circuit

$$I_{(t)} = \frac{V}{R}\left(1 - e^{-Rt/L}\right) \text{ (A)}$$

Where:V is in volts, R is in ohms, L is in henries, t is in seconds, e is the base of the Natural Logarithm = 2.71828

Time response of series RL and RC circuit

II B.Tech,I – Semester   Experiment No. 8(a) &(b)

The **Time Constant**, (τ) of the LR series circuit is given as L/R and in which V/R represents the final steady state current value after five time constant values. Once the current reaches this maximum steady state value at 5τ, the inductance of the coil has reduced to zero acting more like a short circuit and effectively removing it from the circuit.

Therefore the current flowing through the coil is limited only by the resistive element in Ohms of the coils windings. A graphical representation of the current growth representing the voltage/time characteristics of the circuit can be presented as.

Transient Characteristics Curves
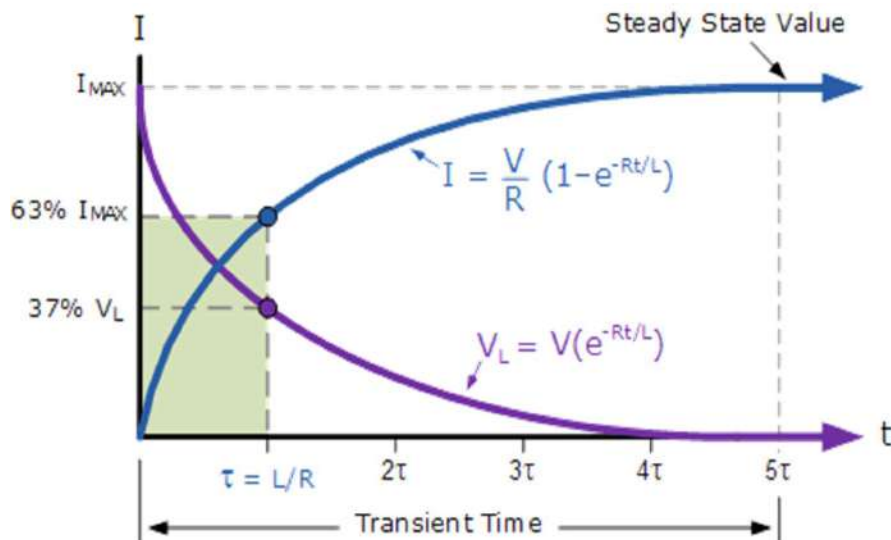
Since the voltage drop across the resistor, V_R is equal to I*R (Ohms Law), it will have the same exponential growth and shape as the current. However, the voltage drop across the inductor, V_L will have a value equal to: $Ve^{(-Rt/L)}$. Then the voltage across the inductor, V_L will have an initial value equal to the battery voltage at time t = 0 or when the switch is first closed and then decays exponentially to zero as represented in the above curves.

The time required for the current flowing in the LR series circuit to reach its maximum steady state value is equivalent to about **5 time constants** or 5τ. This time constant τ, is measured by $τ = L/R$, in seconds, where R is the value of the resistor in ohms and L is the value of the inductor in henries. This then forms the basis of an RL charging circuit were 5τ can also be thought of as "5*(L/R)" or the transient time of the circuit.
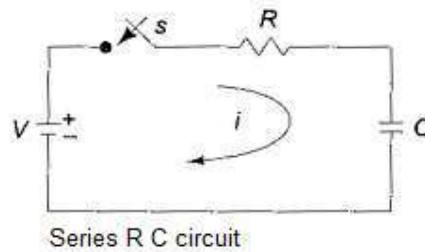
Time response of series RL and RC circuit

II B.Tech,I – Semester   Experiment No. 8(a) &(b)

Transient Response of RC Circuit:

Consider a Transient Response of RC Circuit consisting of resistance and capacitance as shown in figure below.

Series R C circuit

The capacitor in the circuit is initially uncharged, and is in series with a resistor. When the switch S is closed at t = 0, we can determine. the complete solution for the current. Application of the Kirchhoff's voltage law to the circuit results in the following differential equation.

$$V = Ri + \frac{1}{C}\int i\, dt$$

By differentiating the above equation, we get

$$0 = R\frac{di}{dt} + \frac{i}{C}$$

$$\frac{di}{dt} + \frac{1}{RC}i = 0$$

Above equation is a linear differential equation with only the complementary function. The particular solution for the above equation is zero. The solution for this type of differential equation is

$$i = ce^{-t/RC}$$

Here, to find the value of c, we use the initial conditions.
In the Transient Response of RC Circuit shown in figure, switch S is closed at t=0; Since the capacitor never allows sudden changes in voltage, it will act as a short circuit at t=0⁺. So, the current in the circuit at t=0⁺ is V/R

At $t = 0$, the current $i = \dfrac{V}{R}$

Substituting this current in equation of current obtained after differentiation, we get

$$\frac{V}{R} = c$$
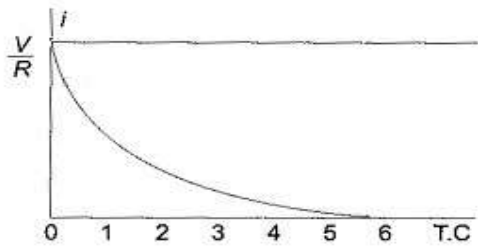
The current equation becomes

$$i = \frac{V}{R}e^{-t/RC}$$

When switch S is closed, the response decays with time as shown in Fig. 12.7.

Fig. 12.7

In the solution, the quantity RC is the time constant, and is denoted by τ,
where τ = RC sec
After 5 TC, the curve reaches 99 per cent of its final value. In the main RC circuit, we can find out the voltage across each element by using the current equation. Voltage across the resistor is

$$v_R = Ri = R \times \frac{V}{R} \, e^{-(1/RC)t} \, ; \, v_R = V e^{-\frac{t}{RC}}$$

Similarly, voltage across the capacitor is

$$v_C = \frac{1}{C} \int i \, dt$$

$$= \frac{1}{C} \int \frac{V}{R} \, e^{-t/RC} \, dt$$

$$= -\left(\frac{V}{RC} \times RC \, e^{-t/RC} \right) + c = - V e^{-t/RC} + c$$

At t = 0, voltage across capacitor is zero

$$c = V$$

$$v_C = V(1 - e^{-t/RC})$$

The responses are shown in figure below.

Voltage response across R and C.

II B.Tech,I – Semester   Experiment No. 8(a) &(b)

Circuit diagrams:

Series RL circuit:

Tabular column:

S.No.	Input voltage (V)	Output voltage(V)	I= (V/R) mA	t (sec)

Series RC circuit:

Tabular column:

S.No.	Input voltage (V)	Output voltage(V)	I= (V/R) mA	t (sec)

Expected graphs:

Response of RL series circuit.

I = voltage/R in mA

Response of RC series circuit.

I = voltage/R in mA
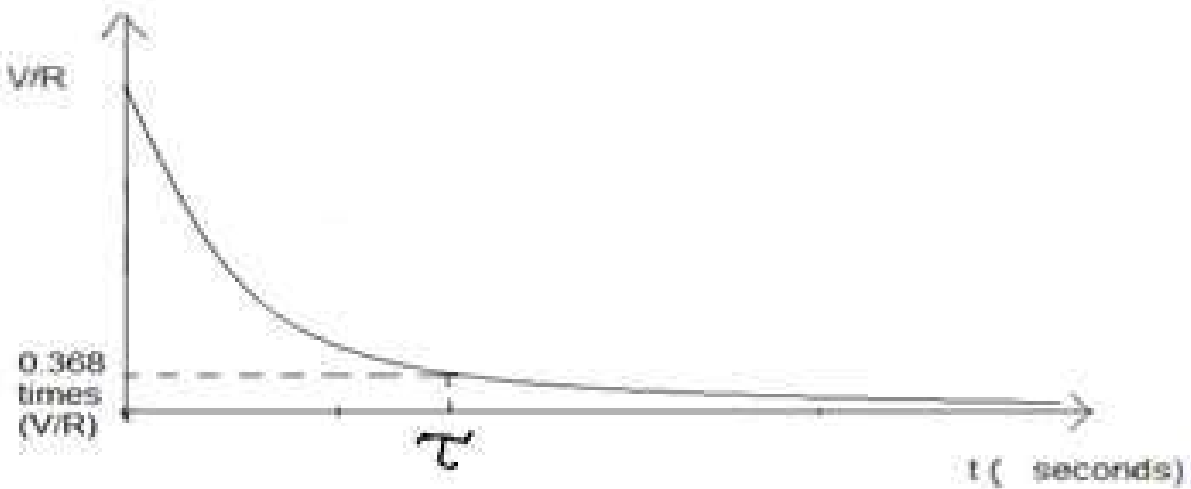
CALCULATIONS:

Theoretical calculation: (Has to be done before starting the experiment, for reference)

For R-L series circuit:

$\tau = L/R$.

For R-C series circuit:

$\tau = R * C$.

Practical calculation: (Using an oscilloscope, 'τ' is calculated by inspecting the response curve in channel -2 of the CRO.)

For R-L series circuit:

The place where $V = 63\% \times V_0$ (63% of the final value, as shown in figure-3 for RL series circuit) has to be located and the corresponding time at which this occurs is noted. This time is the time constant, τ.

For R-C series circuit:

The place where $V = 37\% \times V_0$ (37% of the final value as shown in figure-3 for RC series circuit) has to be located and the corresponding time at which this occurs is noted. This time is the time constant, τ.

PROCEDURE:-

1. Connections are made as per the circuit diagram as shown in the figure-1.
2. Function Generator and Channel-1(CH-1) of the CRO are connected at the input terminals of the trainer circuit board.
3. Channel-2(CH-2) of the CRO is connected across the resistor.
4. A periodic square wave input of 5V peak to peak is applied at a frequency of about 2KHz.
5. From the wave form of current in CRO, the time-constant is measured as explained in the theory.
6. The applied voltage is varied to 8V and 10V and the procedure is repeated as explained in (4) & (5), to observe the change in the value of time constant with change in the input voltage.
7. Connections are made as per the circuit diagram as shown in figure- 2.
8. Steps (2) to (6) are repeated.

RESULT:-

Note: Graphs need to be inserted.

II B.Tech I Semester   Experiment 9(a)

TWO PORT NETWORK PARAMETERS: Impedance(Z) and admittance(Y) parameters.

Aim: To determine Z and Y parameters for the given network and check the symmetry and reciprocity conditions experimentally and verify the same with theoretical values.

Apparatus:

S.NO.	Name of the Apparatus	Range	Quantity
1	Regulated power supply	(0-30V)	1
2	Bread board	-	1
3	Ammeter	(0-200mA)	2
4	Voltmeter	(0-20V)	2
5	Resistor	2.2kΩ	2
6	Resistor	470Ω	3

Theory:
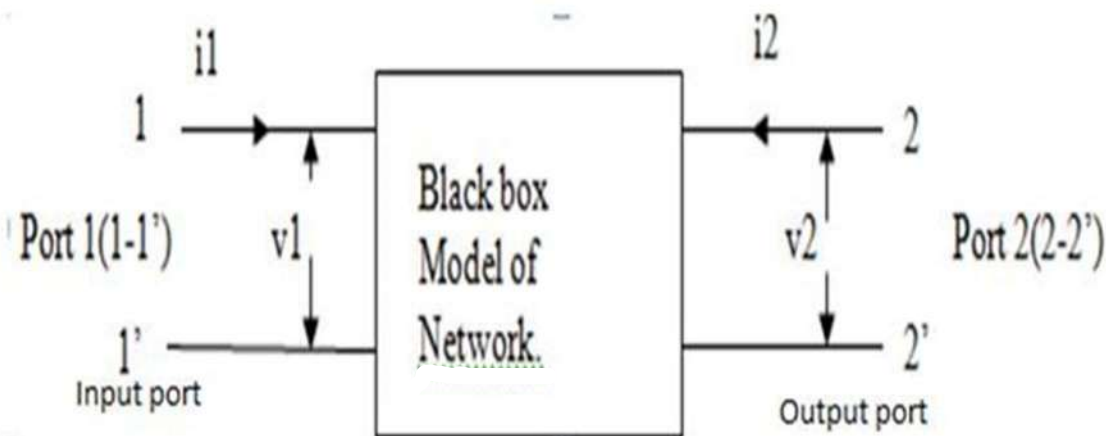
II B.Tech I Semester   Experiment 9(a)

Z parameter is a factor by which input voltage and current & output voltage and current of two port network is related with. For any two port network, input voltage V_1 and output voltage V_2 can be expressed in terms of input current I_1 and output current I_2 respectively. It is also known as open circuit impedance parameter. The unit of impedance parameter is ohm(Ω).

Z parameter in terms of input voltage V_1 and output voltage V_2 & input current I_1 and output current I_2 is given as below.

[V] = [Z] [I] ----(1)

Where [Z] is impedance matrix,
[V] and [I] are voltage and current matrix.
Therefore, in matrix form the input and output voltage and current can be represented a below.

$$\begin{bmatrix} V_1 \\ V_2 \end{bmatrix} = \begin{bmatrix} Z_{11} & Z_{12} \\ Z_{21} & Z_{22} \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix}$$ ------(2)

Calculation of Z Parameter:
Let us consider a two port network shown in figure 1.

As per the definition,

$V_1 = Z_{11}I_1 + Z_{12}I_2$ ......(3)
$V_2 = Z_{21}I_1 + Z_{22}I_2$ ....(4)

Assuming the output of the two port network to be open, which means no current exits, therefore I2 = 0.

Now putting $I_2 = 0$ in (3), we get

$V_1 = Z_{11}I_1$
$Z_{11} = (V_1 / I_1)$ -----(5)
Equation (5) can we re-written as
$$Z_{11} = \left.\frac{V_1}{I_1}\right|_{I_2=0}$$ ---(5a)

Similarly putting $I_2 = 0$ in (4), we get
$V_2 = Z_{21}I_1$
$Z_{21} = (V_2 / I_1)$ ---(6)
$$Z_{21} = \left.\frac{V_2}{I_1}\right|_{I_2=0}$$ ---(6a)

2

Again assuming input port of the two port network to be open, the input current $I_1 = 0$.

Now putting $I_1 = 0$ in (3), we get
$V_1 = Z_{12}I_2$
$Z_{12} = (V_1 / I_2)$ ----(7)

$$Z_{12} = \frac{V_1}{I_2}\bigg|_{I_1=0} \quad \text{.....(7a)}$$

Similarly putting $I_1 = 0$ in (4), we get
$V_2 = Z_{22}I_2$
$Z_{22} = (V_2 / I_2)$ -----(8)

$$Z_{22} = \frac{V_2}{I_2}\bigg|_{I_1=0} \quad \text{------(8a)}$$

Condition for symmetry of Z- parameters is $Z_{11} = Z_{22}$ and for reciprocity is $Z_{12} = Z_{21}$.

Significance of different Z Parameters:

1. Z_{11} is the ratio of input voltage and input current when the output port is open; therefore it is known as input driving point impedance.

In electrical machines, this can be understood as a transformer at no load.

Where the input voltage is primary supply voltage V_s and the input current is excitation current, I_e. Thus, the input driving point impedance Z_{11} for this will be (V_s / I_e).

2. Z_{22} is the ratio of output voltage and output current when input port is open; therefore it is called output driving point impedance of the network.

3. Z_{12} is the ratio of input voltage and output current when input port is open; therefore it is called reverse transfer impedance.

4. Z_{21} is the ratio of output voltage and input current when output port is open; therefore it is called forward transfer impedance.

II B.Tech I Semester   Experiment 9(a)

Y- Parameters:

Y parameter of two port network is a 2×2 admittance matrix as shown is equation. Since **admittance** is the ratio of circuit current and voltage, therefore this admittance matrix gives the relationship between the input and output current and voltage of the network. It is also known as short circuit parameter or admittance parameter. The unit of admittance parameter is Siemens(S) or mho ($1/\Omega$).

The Y parameter for a two port network is defined as
$$[I] = [Y][V] \quad ----(9)$$
where $[Y]$ is the admittance matrix, $[I]$ and $[V]$ are the current and voltage matrix.

$$\begin{bmatrix} I1 \\ I2 \end{bmatrix} = \begin{bmatrix} Y11 & Y12 \\ Y21 & Y22 \end{bmatrix} \begin{bmatrix} V1 \\ V2 \end{bmatrix} \quad ----(10)$$

From the above matrix representation of two port network, it is clear that there are four admittance parameters i.e. Y_{11}, Y_{12}, Y_{21} and Y_{22}.

Calculation of Y Parameter:

Let us consider a two port network. Let V_1, I_1, V_2 and I_2 are the input voltage, input current, output voltage and output current respectively.

The relationship between the input and output quantities for the network in figure 1, is obtained using equation (9) as shown below.
$$I_1 = Y_{11}V_1 + Y_{12}V_2 \quad ......(11)$$
$$I_2 = Y_{21}V_1 + Y_{22}V_2 \quad ....(12)$$
Assuming the output of the two port network to be short circuited, the output voltage will be zero, i.e., $V_2 = 0$.
Now, putting $V_2 = 0$ in (11), we get,
$$I_1 = Y_{11}V_1$$
$$Y_{11} = (I_1 / V_1)$$
$$Y_{11} = \frac{I_1}{V_1}\bigg|_{V_2=0} \quad ---(13)$$

Similarly putting $V_2 = 0$ in (12), we get
$$I_2 = Y_{21}V_1$$
$$Y_{21} = (I_2 / V_1)$$
$$Y_{21} = \frac{I_2}{V_1}\bigg|_{V_2=0} \quad ---(14)$$

Again, assuming input port of the two port network to be short circuited, the input voltage will be zero, $V1 = 0$.

Now putting $V_1 = 0$ in (11), we get

$I_1 = Y_{12}V_2$

$Y_{12} = (I_1 / V_2)$

$$Y_{12} = \frac{I_1}{V_2}\bigg|_{V_1=0} \text{--- (15)}$$

Similarly putting $V_1 = 0$ in (12), we get

$I_2 = Y_{22}V_2$

$Y_{22} = (I_2 / V_2)$

$$Y_{22} = \frac{I_2}{V_2}\bigg|_{V_1=0} \text{--- (16)}$$

Condition for symmetry of Y- parameters is $Y_{11} = Y_{22}$ and for reciprocity is $Y_{12} = Y_{21}$.

Significance of different Y Parameters:

1. Y_{11} is the ratio of input current and voltage when the output port is short circuited, therefore it is known as input driving point admittance.

2. Y_{22} is the ratio of output current and voltage when input port is short circuited, therefore it is called output driving point admittance of the network.

3. Y_{12} is the ratio of input current and output voltage when input port is short circuited, therefore it is called reverse transfer admittance.

4. Y_{21} is the ratio of output current and input voltage when output port is short circuited, therefore it is called forward transfer admittance.
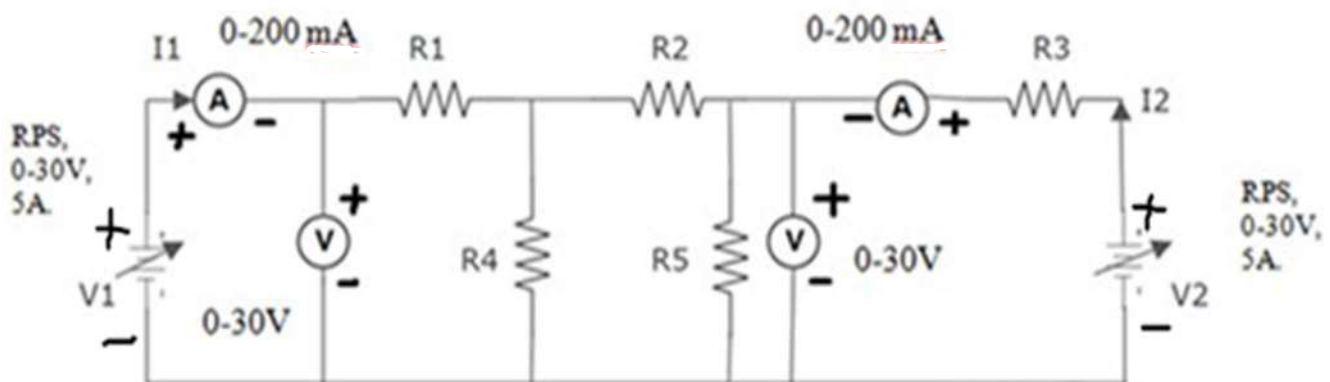
CIRCUIT DIAGRAM:

Figure 2: Main circuit for finding Z and Y parameters.

II B.Tech I Semester   Experiment 9(a)

Z parameters :

(i) Finding Z_{11} & Z_{21} parameters with port-2 Open circuited & voltage V_1 is applied at port-1.
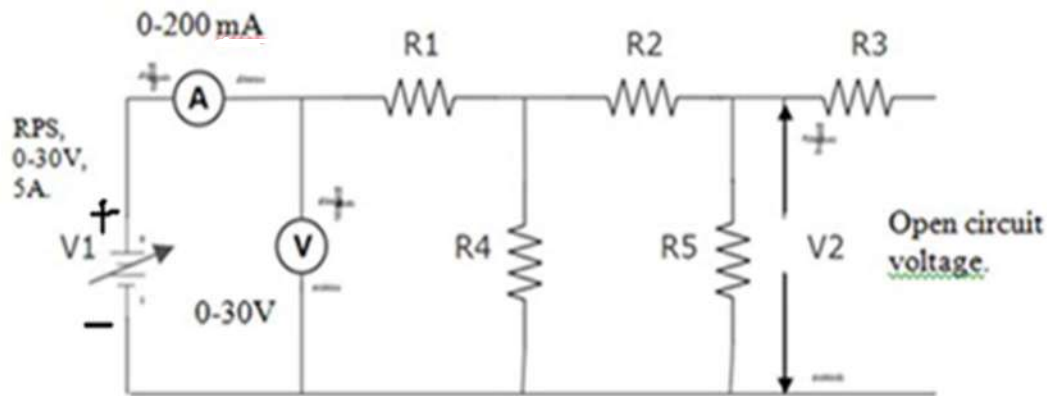

Figure 3: Network to find Z_{11} & Z_{21} parameters.

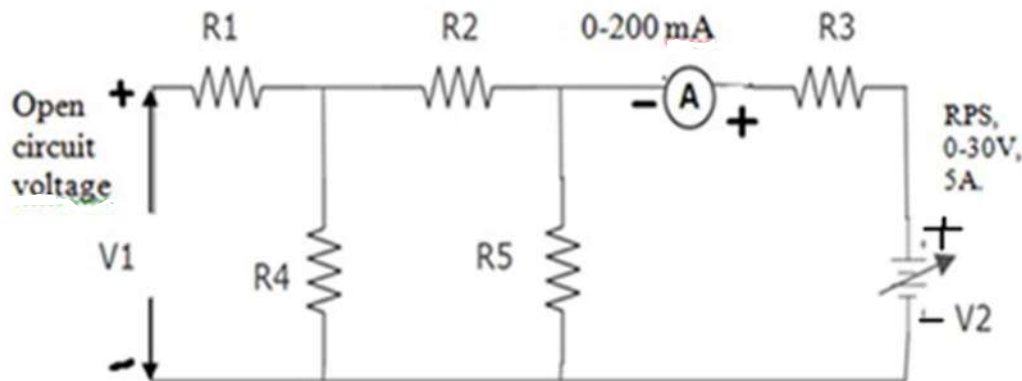(ii)Finding Z_{12} & Z_{22} parameters with port-1 open circuited & voltage V_2 is applied at port-2.

Figure 4: Network to find Z_{12} & Z_{22} parameters.

II B.Tech I Semester   Experiment 9(a)

Y parameters :

(i) Finding Y_{11} & Y_{21} parameters with port-2 short circuited & voltage V_1 is applied at port-1.
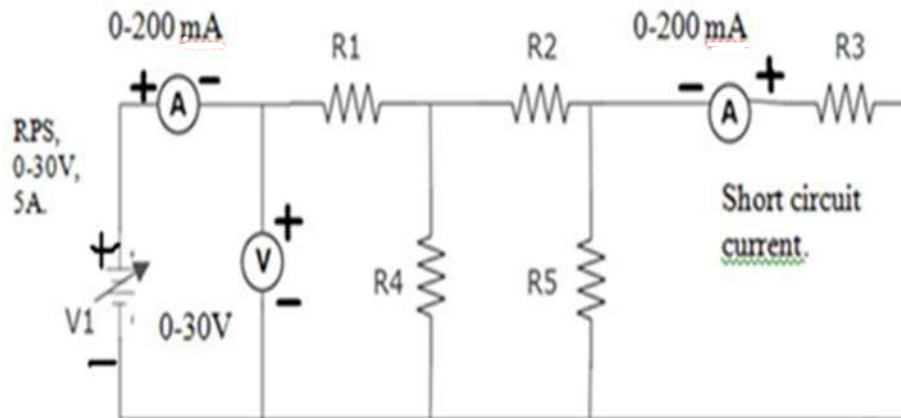

Figure 5: Network to find Y_{11} & Y_{21} parameters.

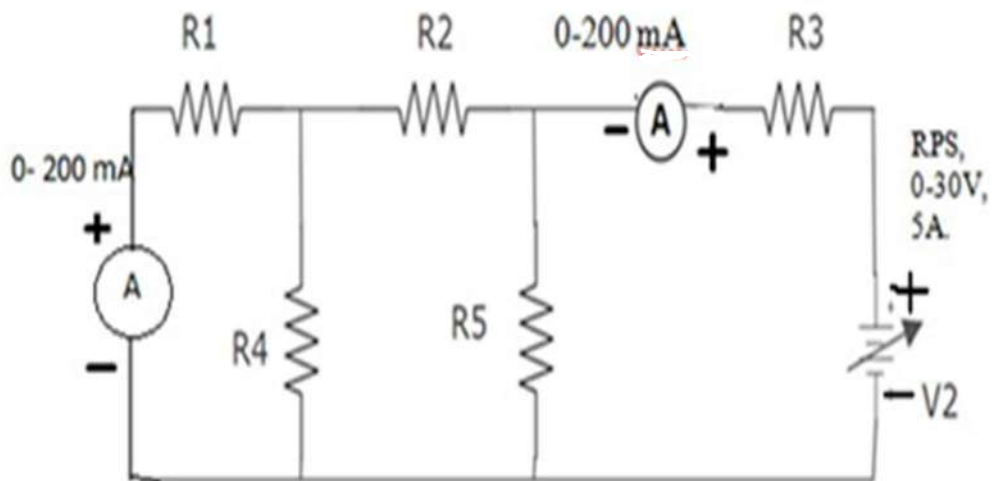(ii) Finding Y_{12} & Y_{22} parameters with port-1 short circuited & voltage V_2 is applied at port-2.

Figure 6 : Network to find Y_{12} & Y_{22} parameters.

Observations and calculations :

Given R1=R2=R3=470Ω, R4=R5=2.2kΩ .

Z Parameters:

(i)Finding Z_{11} & Z_{21} parameters with port-2 Open circuited & voltage V_1 is applied at port-1.

$V_1(V)$ $I_1(mA)$	$V_2(V)$	$Z_{11} = \frac{V_1}{I_1}$ Ω	$Z_{21} = \frac{V_2}{I_1}$ Ω

(ii)Finding Z_{12} & Z_{22} parameters with port-1 open circuited & voltage V_2 is applied at port-2.

$V_2(V)$	$I_2(mA)$	$V_1(V)$	$Z_{12} = \frac{V_1}{I_2}$ Ω	$Z_{22} = \frac{V_2}{I_2}$ Ω

Calculations for Z-parameters:

II B.Tech I Semester   Experiment 9(a)

Y parameters:

(i) Finding Y_{11} & Y_{21} parameters with port-2 short circuited & voltage V_1 is applied at port-1.

$V_1(V)$	$I_1(mA)$	$I_2(mA)$	$Y_{11} = \frac{I_1}{V_1}$ ℧	$Y_{21} = \frac{I_2}{V_1}$ ℧

(ii) Finding Y_{12} & Y_{22} parameters with port-1 short circuited & voltage V_2 is applied at port-2.

$V_2(V)$	$I_2(mA)$	$I_1(mA)$	$Y_{12} = \frac{I_1}{V_2}$ ℧	$Y_{22} = \frac{I_2}{V_2}$ ℧

Calculations for Y parameters:

II B.Tech I Semester   Experiment 9(a)

Procedure:

Z Parameters:

1. Connections are made as per the network shown in figure 3.
2. Readings of V_1, I_1 & V_2 are noted from the respective meters, with port-2 in open circuit condition,
3. The parameters Z_{11} & Z_{21} are calculated.
4. Connections are made as per the network shown in figure 4.
5. Readings of V_2, I_2 & V_1 are noted from the respective meters, with port-1 in open circuit condition.
6. The parameters Z_{22} & Z_{12} are calculated.
7. The practical values of these parameters have to be compared with the theoretical calculations.

Y Parameters:

1. Connections are made as per the network shown in figure 5.

2. Readings of V_1, I_1 & I_2 are noted from the respective meters, with port-2 in short circuit condition.
3. The parameters Y_{11} & Y_{21} are calculated.
4. Connections are made as per the network shown in figure 6.
5. Readings of V_2, I_2 & I_1 are noted from the respective meters, with port-1 in short circuit condition.
6. The parameters Y_{12} & Y_{22} are calculated.
7. The practical values of these parameters have to be compared with the theoretical calculations.

II B.Tech I Semester   Experiment 9(a)

Result:

Comparison table:

Parameters & Conditions.	Theoretical values	Practical values.
Z_{11} Ω		
Z_{12} Ω		
Z_{21} Ω		
Z_{22} Ω		
Y_{11} $\mho$		
Y_{12} $\mho$		
Y_{21} $\mho$		
Y_{22} $\mho$		
Condition for Reciprocity		
Condition for Symmetry		

II B.Tech I Semester   Experiment 9(a)

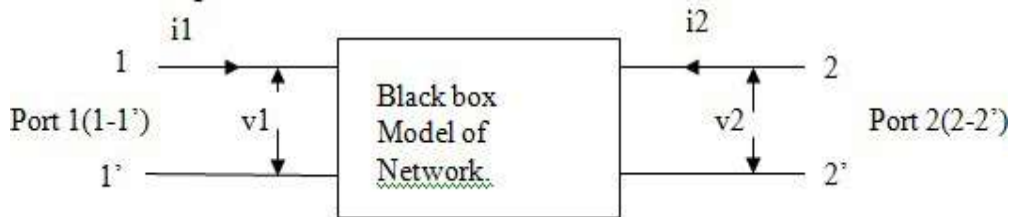### TWO PORT NETWORK PARAMETERS (A,B,C,D & h)

Aim: To determine transmission parameters-(A,B,C,D) and hybrid (h) parameters.

Apparatus:

S.NO.	Name of the Apparatus	Range	Quantity
1	Regulated power supply	(0-30V)	1
2	Bread board	-	1
3	Ammeter	(0-200mA)	2
4	Voltmeter	(0-20V)	2
5	Resistor	2.2kΩ	2
6	Resistor	470Ω	3

Theory:

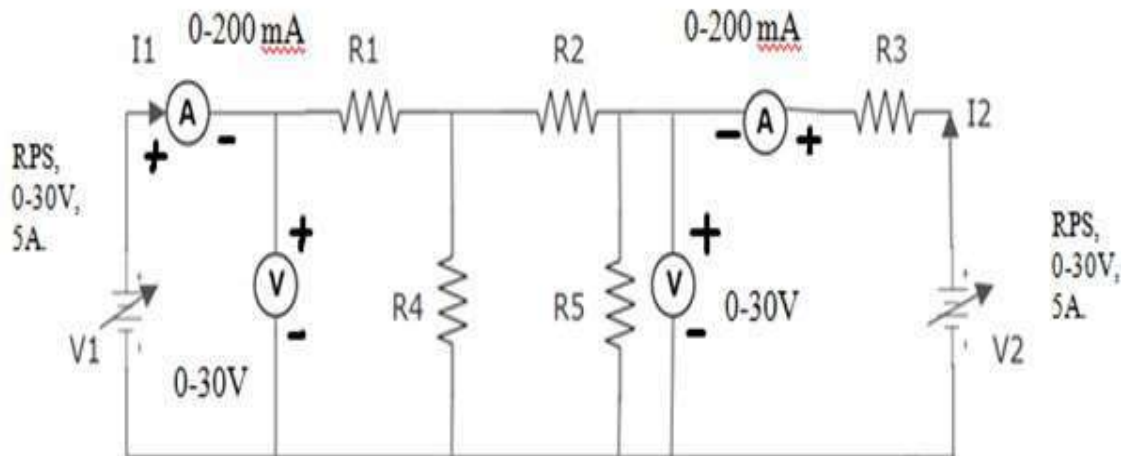**Basic two port network:**

MAIN CIRCUIT DIAGRAM:

Figure 1: Main network.

ABCD parameters (Transmission Parameters)

ABCD parameters are also known as "Transmission Parameters". In these parameters, the voltage and current at the sending end terminals can be expressed in terms of voltage and current at the receiving end. Thus,

$V_1 = AV_2 - BI_2 \dots \dots \dots (i)$

$I_1 = CV_2 - DI_2 \dots \dots (ii)$

Where $A = \frac{V_1}{V_2}|I_2 = 0$; A is called Reverse Voltage ratio.

$B = \frac{-V_1}{I_2}|V_2 = 0$; "B" is called Transfer Impedance.

$C = \frac{I_1}{V_2}|I_2 = 0$; "C" is called Transfer Admittance.

$D = \frac{-I_1}{I_2}|V_2 = 0$; "D" is called Reverse Current ratio.

Hence,

Condition for symmetry Is A = D.

Condition for reciprocity is AD- BD = 1.

Hybrid (OR) h- Parameters

In h-parameters of two port network, voltage of the input port and the current of the output port are expressed in terms of the current of the input port and the voltage of the output port. Due to this reason, these parameters are called as hybrid parameters.
Hybrid parameters are expressed as:

$V_1 = h_{11}I_1 + h_{12}V_2 \dots \dots \dots (i)$

$I_2 = h_{21}I_1 + h_{22}V_2 \dots \dots \dots (ii)$

Where,

$h_{11} = \frac{V_1}{I_1}|V_2 = 0$,

$h_{12} = \frac{V_1}{V_2}|I_1 = 0$,

$h_{21} = \frac{I_2}{I_1}|V_2 = 0$,

$h_{22} = \frac{I_2}{V_2}|I_1 = 0$.

h_{11} & h_{12} are Input Impedance and Output Admittance respectively.
h_{21} & h_{22} are Forward Current Gain and Reverse Voltage gains respectively.
Hence,
Condition for symmetry is $h_{11}h_{22} - h_{21}h_{12} = 1$.
Condition for reciprocity is $h_{12} = -h_{21}$.

ABCD parameters (Transmission Parameters)

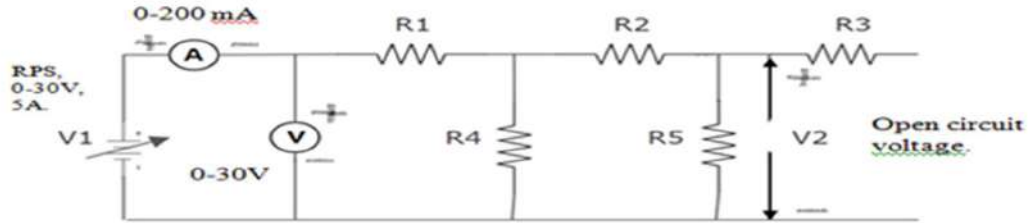(i) Finding A&C parameters with port-2 Open circuited & voltage V_1 is applied at port-1 as shown in figure2(a).

Figure 2(a): Network to determine A and C.

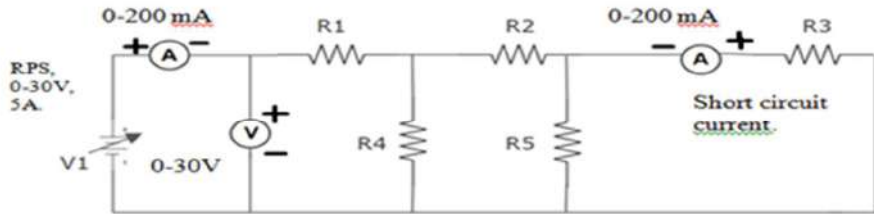(ii)Finding B&D parameters with port-2 Short circuited & voltage V_1 is applied at port-1as shown in figure2(b).

Figure 2(b): Network to determine B and D.

Hybrid(h) – Parameters:

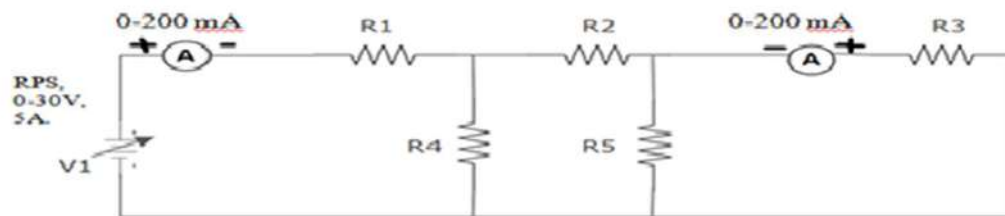(i)When port-2 is Short circuited & voltage V_1 is applied at port-1as shown in figure3(a).

Figure 3 (a): Network to determine h_{11} and h_{21}.

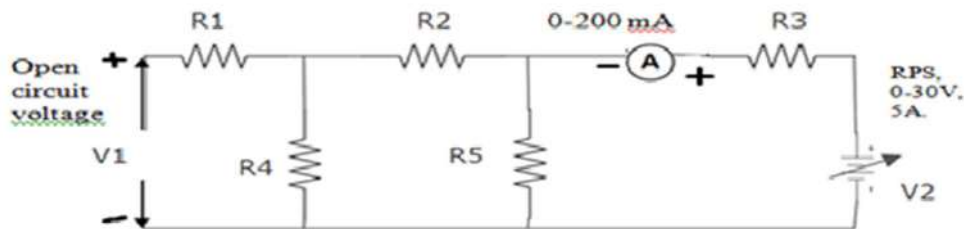(ii) When port-1 is Open circuited & voltage V_2 is applied at port-2, as shown in figure 3(b).

Figure 3 (b): Network to determine h_{22} and h_{12}.

Observations and calculations:

  Give R1=R2=R3=470Ω and R4=R5=2.2kΩ .

ABCD Parameters:

(i)Finding A&C parameters with port-2 Open circuited & voltage V_1 is applied at port-1, Figure 2(a).

$V_1(V)$	$I_1(mA)$	$V_2(V)$	$A = \dfrac{V_1}{V_2}$	$C = \dfrac{I_1}{V_2}(m\mho)$

(ii)Finding B&D parameters with port-2 Short circuited & voltage V_1 is applied at port-1, Figure 2(b).

$V_1(V)$	$I_2(mA)$	$I_1(mA)$	$B = \dfrac{-V_1}{I_2}(k\Omega)$	$D = \dfrac{-I_1}{I_2}$

Hybrid (h) parameters:

(i)When port-2 is Short circuited & voltage V_1 is applied at port-1, figure 3(a).

$V_1(V)$	$I_1(mA)$	$I_2(mA)$	$h_{11} = \dfrac{V_1}{I_1}(k\Omega)$	$h_{21} = \dfrac{I_2}{I_1}$

(ii) When port-1 is Open circuited & voltage V_2 is applied at port-2, figure 3(b).

$V_1(V)$	$I_2(mA)$	$V_2(V)$	$h_{12} = \dfrac{V_1}{V_2}$	$h_{22} = \dfrac{-I_2}{V_2}(m\mho)$

Procedure:

ABCD Parameters:

1. Connections are made as per the network shown in figure 2(a).
2. Readings of V_1, I_1, V_2 are noted from the respective meters, with port-2 in open circuit condition,
3. The parameters A & C are calculated.
4. Connections are made as per the network shown in figure 2(b).
5. Readings of V_1, I_1, I_2 are noted from the respective meters, with port-2 in short circuitcondition.
6. The parameters B & D are calculated.
7. The practical values of these parameters have to be compared with the theoretical calculations.

Hybrid parameters:

1. Connections are made as per the network shown in figure 3(a).

2. Readings of V_1, I_2, I_1 are noted from the respective meters, with port-1 in open circuit condition.
3. The parameters h_{11}, h_{21} are calculated.
4. Connections are made as per the network shown in figure 3(b).
5. Readings of V_1, I_2, V_2 are noted from the respective meters, with port-2 in shortcircuit condition.
6. The parameters h_{12}, h_{22} are calculated.
7. The practical values of these parameters have to be compared with the theoretical calculations.

Result:

Comparison table:

Parameters & Conditions.	Theoretical values	Practical values.
A		
B		
C		
D		
h_{11}		
h_{12}		
h_{22}		
h_{21}		
Condition for Reciprocity		
Condition for Symmetry		

Waveform Synthesis Using Laplace Transform

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AIM: To obtain the Laplace transform for the a) Pulse wave form and b) the triangular pulse using waveform synthesis

Theory:

In waveform synthesis, the unit step function u(t) and other functions serve as building blocks in constructing other waveforms. Once the waveforms are synthesized in the form of other functions, Laplace transform is found and simplified.

**a) To obtain the Laplace transform of the pulse using waveform synthesis**

For example, we may describe a pulse waveform in terms of unit step functions. A pulse of unit amplitude from *t=a* to *t=b* can be formed by taking the difference between the two step functions.
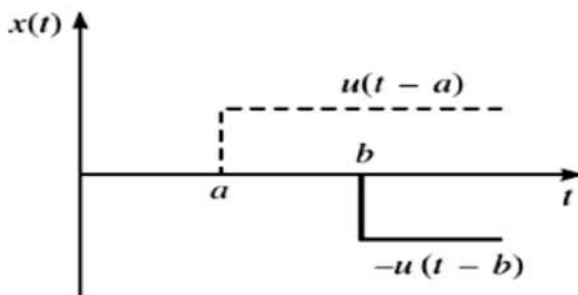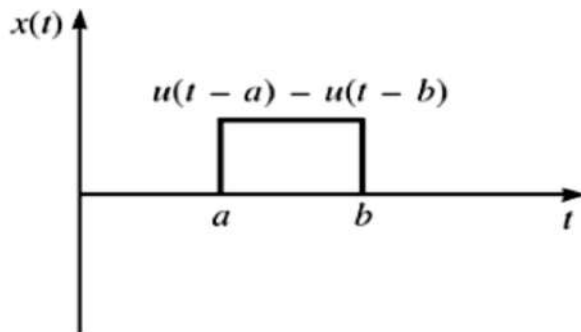
$$x(t) = u(t - a) - u(t - b)$$

$$\text{Hence } X(s) = \; e^{-as}.\frac{1}{s} - e^{-bs}.\frac{1}{s}$$

b) To obtain the Laplace transform of the triangular Wave using waveform synthesis
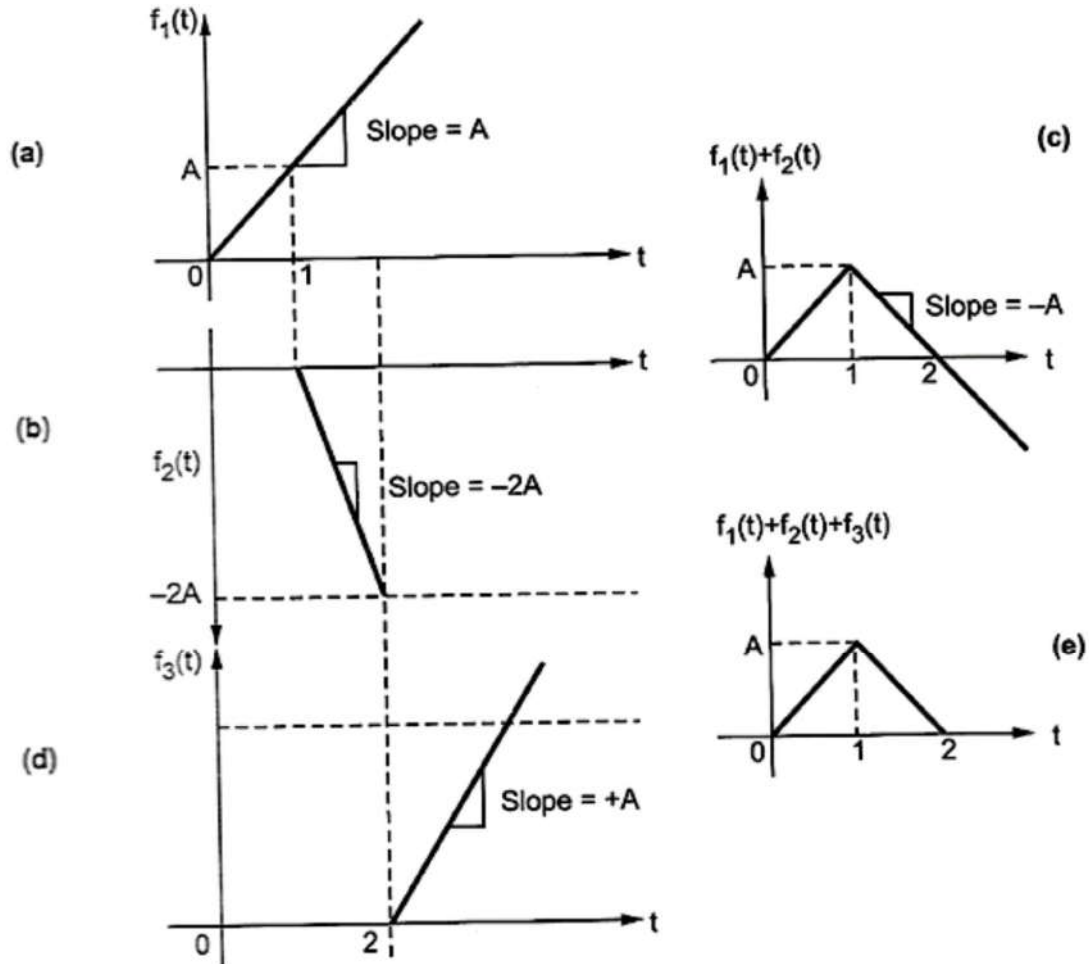
As shown in the figure above, a ramp of slope A starting at t=0 is taken as f1(t). The Function f2(t) is the ramp of slope -2A starting at t=1. When we add f1(t) and f2(t) we get the signal shown in figure (c). Observe that a negative going ramp of slope (A-2A=-A) starts at t=1. To cancel the part of this ramp after t≥2, a positive going ramp of slope +A in figure (d) is added. Then we get the required triangular pulse of Figure (e).

With the help of step functions, the ramp functions in the figure above can be expressed as follows:

i) $f_1(t) = A.t.u(t)$

        {The function u(t)=1 for t>0; It indicates that ramp is present only for t≥0}

ii) $f_2(t) = -2A.(t-1).u(t-1)$

        {The function u(t-1)=1 for t>1; It indicates that ramp is present only for t≥1}

iii) $f_3(t) = A.(t-2).u(t-2)$

Therefore, $f(t) = f_1(t) + f_2(t) + f_3(t)$

$$= A.t.u(t) - 2A.(t-1).u(t-1) + A.(t-2).u(t-2)$$

Since *u(t), u(t-1) and u(t-2)* have values of „1‟ and they just represent the time shifts and directions of ramp functions, they can be dropped in this expression. Laplace transform of above equation becomes

$$A.\frac{1}{s^2} - 2.A.\frac{e^{-s}}{s^2} + A.\frac{e^{-2s}}{s^2}$$

Procedure:

1. Open MATLAB software.
2. For programming select NEW SCRIPT, to build up circuit model, select SIMULINK.
3. Programs mentioned in (i), (ii) and circuit models in figure (a) and (b) are rigged up and executed.

    (i)   PROGRAM FOR PULSE WAVE SYNTHISIS

```
clc;
close all;
clear all;
% WAVE FORM SYNTHISIS OF A PULSE WAVE FORM%
syms f t s;
a=2;
b=5;
f1=heaviside(t-a)  %  unit step function starts at 'a ' sec
f2=-heaviside(t-b)  %  unit step function starts at 'b' sec
f=f1+f2
FS=laplace(f)
```

    (ii)   PROGRAM FOR TRIANGULAR WAVE SYNTHISIS

```
clc;
close all;
clear all;
% WAVE FORM SYNTHISIS OF A PULSE WAVE FORM%
```

syms f t s;

clc;

A=1;

f1=A*t*heaviside(t) % Ramp function starts at 't=0 '

f2=-2*A*(t-1)*heaviside(t-1) % ramp function at 't=2' sec

f3=A*(t-2)*heaviside(t-2)

f=f1+f2+f3

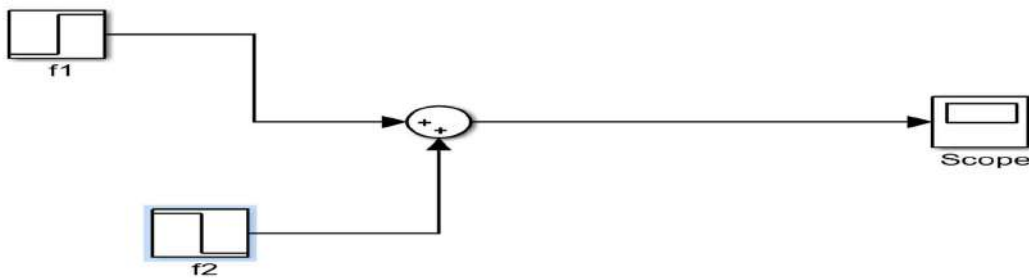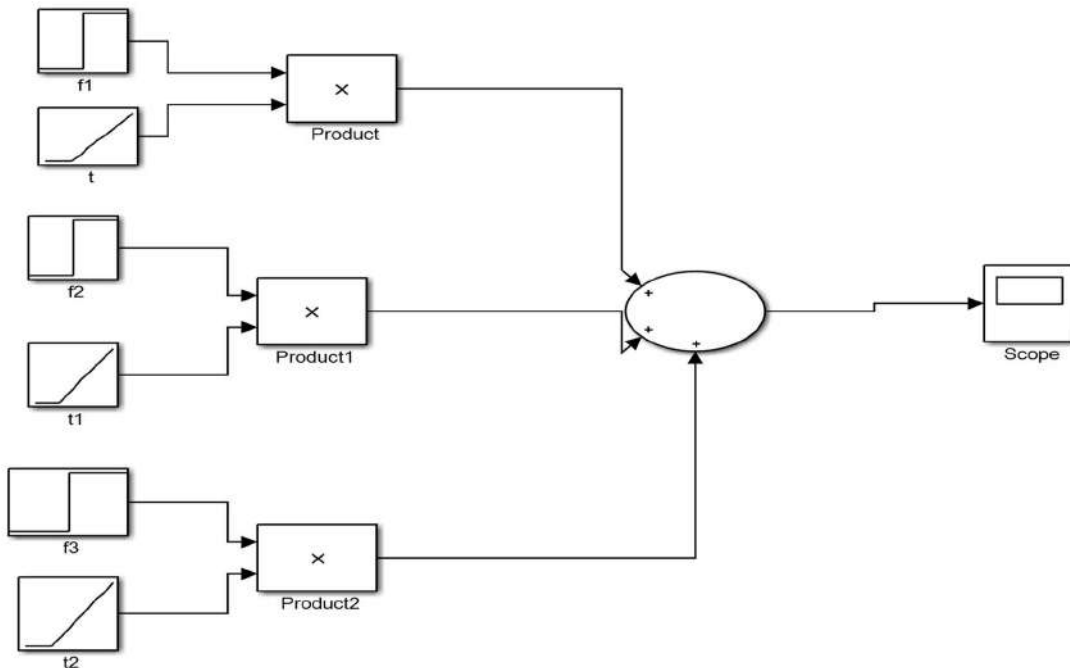FS=laplace(f)

Figure (a) Simulink diagram for Pulse waveform

. Figure (b) Simulink diagram for Triangular waveform

Result: